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'LUSITANO'
UMA NOVA FORMA CULTIVADA DE ARROZ

POR

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O arroz que vamos descrever com o nome de 'Lusitano' foi obtido por hibridação artificial na Estação Agronómica Nacional com o objectivo de vir a substituir as formas rajadas, de fraco valor comercial, ainda em cultura nalgumas regiões orizícolas do norte do País.

O cruzamento foi realizado utilizando-se como progenitor feminino a forma cultivada 'Allorio' pertencente à ssp. *japonica* KATO var. *italica* ALEF. tipo *media* (PIACCO) VASC. e como progenitor masculino a forma cultivada 'Arroz da Terra' também da ssp. *japonica* KATO var. *subdesvauxii* VASC. tipo *longa* (PIACCO) VASC.

Escolheram-se estas duas formas cultivadas de arroz atendendo aos caracteres *precocidade,* existente em ambas e considerado indispensável para aquelas regiões, *cariopse branca* do 'Allorio' e *resistência ao meio cultural* representado pelo 'Arroz da Terra', precisamente um dos rajados mais cultivados nalgumas localidades de Aveiro.

O híbrido resultante deste cruzamento corresponde quase completamente aos objectivos que se pretendem pois apresenta grande precocidade, cariopse branca e resistência ao meio; morfològicamente é muito semelhante ao 'Arroz da Terra'.

A emasculação foi feita usando o processo do corte das glumelas e arranque das anteras e a polinização por deposição de uma antera, prèviamente rasgada, sobre os estigmas da flor castrada.

A planta híbrida da primeira geração (F_1), de que interessa referir apenas as características mais em evidência, apresentava folhas e colmos verdes, aurículas e nós violáceos, dente apical ou base da arista vermelha.

O progenitor feminino possuia folhas, colmos, aurículas e nós verdes no desenvolvimento, amarelos palha na maturação, dente apical amarelo palha.

O progenitor masculino apresentava folhas, colmos, aurículas e nós verdes no desenvolvimento, amarelos palha na maturação, dente apical violáceo.

A segunda geração foi caracterizada por uma variada segregação em que se podiam notar diferentes combinações fenotípicas dos seguintes caracteres: dente apical violáceo ou amarelo palha, colmos verdes ou riscados de violáceo, nós verdes ou violáceos, cariopses brancas ou rajadas.

De todas as que nos pareceu possuir maior interesse correspondia aos seguintes caracteres: dente apical amarelo palha, colmos verdes, nós verdes, cariopse branca.

Foi sobre plantas representativas deste fenotipo que se iniciou a selecção genealógica que teve como resultado o arroz, a que foi dado o nome de 'Lusitano', de que vamos fazer a descrição botânica em confronto com a dos seus progenitores VASCONCELLOS (1953), registando também outros dados de possível interesse para a sua apreciação cultural.

'ALLORIO' ♀

Estatura mediana.

Colmos geniculados na base, por vezes ligeiramente, com entrenós de comprimento mediano.

Nós do colmo um pouco intumescidos, glabros, de coloração verde-clara.

Entrenós e folhas amarelos na maturação.

Folha superior com a lígula comprida; limbo erecto-patente ou patente, mediano de largura, com a base quase sempre esbranquiçada.

Emborrachamento precoce.

Pedúnculo de comprimento geralmente mediano, delgado e direito.

Panícula com o nó inferior delgado e glabrescente, pendente, fechada, mediana, pouco ramificada.

Espigueta bem firme, mediana, larga, espessa, verde no desenvolvimento, amarelo palha na maturação.

QUADRO I

Medições sobre 100 espiguetas

	Valores observados (mm)		$\bar{x}$	$s_{\bar{x}}$	c. v.
	Mínimo	Máximo			
Comprimento . .	7,63	8,62	8,061	0,227	2,8
Largura	3,05	3,66	3,385	0,119	3,5
Espessura . . .	2,04	2,40	2,252	0,068	3,0
Relação $\frac{\text{comp.}}{\text{larg.}}$ . .	2,23	2,60	2,386	0,083	3,5

Glumas geralmente lanceoladas, mais claras e brilhantes que o resto da espigueta e com cerca de um terço do comprimento desta.

Glumela inferior mútica, relativamente pouco vilosa, com a nervura lateral pouco encurvada geralmente equidistante da margem e carena.

Estigmas brancos.

Cariopse mediana de comprimento, larga e espessa; pericarpo branco; albúmen normalmente vítreo e transparente; embrião mediano; cavidade escutelar reentrante.

QUADRO II

Medições sobre 100 cariopses

	Valores observados (mm)		$\bar{x}$	$s_{\bar{x}}$	c. v.
	Mínimo	Máximo			
Comprimento . .	5,53	6,25	5,961	0,160	2,7
Largura	2,68	3,25	2,979	0,110	3,5
Espessura . . .	1,91	2,22	2,073	0,075	3,6
Relação $\frac{\text{comp.}}{\text{larg.}}$ . .	1,84	2,19	2,018	0,080	4,0

Origem forma obtida por selecção do 'Chinês' originário no ano de 1915 pelos produtores Francesco e Marcello Allorio, em Itália.

'ARROZ DA TERRA' ♂

Estatura baixa

Colmos erectos, delgados, de entrenós curtos.

Nós do colmo ligeiramente intumescidos, verdes.

Entrenós e folhas amarelos na maturação e permanecendo os entrenós um tanto esverdeados.

Folha superior com a lígula comprida; limbo patente ou divaricado e estreito, com a base esbranquiçada.

Emborrachamento precoce.

Pedúnculo delgado, curto, direito.

Panícula com o nó inferior glabrescente, um pouco recurvada, fechada, curta, um tanto rala, pouco ramificada.

Espigueta de articulação frágil, comprida, larga, pouco espessa, verde no desenvolvimento, amarelo palha na maturação.

QUADRO III

Medições sobre 100 espiguetas

	Valores observados (mm)		$\bar{x}$	$s_{\bar{x}}$	c. v.
	Mínimo	Máximo			
Comprimento . .	7,67	9,57	8,836	0,330	3,7
Largura	2,91	3,66	3,391	0,131	3,9
Espessura . . .	1,74	2,24	2,054	0,097	4,7
Relação $\frac{\text{comp.}}{\text{larg.}}$ . .	2,37	3,08	2,620	0,137	5,0

Glumas a superior mais ou menos cuspidada, mais claras e brilhantes do que o resto da espigueta e com cerca de um terço do comprimento desta, por vezes maculadas de violáceo-anegrado no cimo.

Glumela inferior mútica ou frequentemente com o dente apical violáceo-anegrado transformado em arista rudimentar ou mesmo

um tanto desenvolvida ([1]); superfície vilosa no cimo; nervura lateral geralmente equidistante da margem e da carena.

Estigmas violáceos.

Cariopse comprida, larga e pouco espessa; pericarpo castanho-avermelhado; albúmen de fractura vítrea quando bem maduro; embrião mediano; cavidade escutelar pouco escavada.

QUADRO IV

Medições sobre 100 cariopses

	Valores observados (mm)		$\bar{x}$	$s_{\bar{x}}$	c. v.
	Mínimo	Máximo			
Comprimento . .	5,83	7,25	6,524	0,219	3,4
Largura	2,51	3,06	2,843	0,118	4,1
Espessura . . .	1,56	2,01	1,806	0,087	4,8
Relação $\frac{\text{comp.}}{\text{larg.}}$ . .	2,06	2,67	2,407	0,125	5,2

Observações: Esta forma é cultivada com os nomes de 'Rajado' e mesmo de 'Carolino', sendo ainda muito apreciada no limite norte da área de cultura de arroz no nosso País. Encontra-se misturada com a que designamos por 'Arroz da Terra de nós escuros'. Tem sobretudo importância em Estarreja, Salreu e proximidades de Aveiro. Também se encontra como impureza noutras searas.

'LUSITANO'

Origem — híbrido de 'Allorio' × 'Arroz da Terra'.

Estatura mediana.

Colmos erectos, delgados, com entrenós de comprimento mediano.

([1]) Na mesma panícula encontram-se todos estes aspectos, excedendo, por vezes, nalgumas espiguetas a arista 4 cm.

Nós do colmo intumescidos, glabros, verdes.

Entrenós e folhas verdes no desenvolvimento e amarelo palha na maturação.

Folha superior com a lígula mediana, limbo mediano, patente com a base esbranquiçada.

Emborrachamento precoce.

Pedunculo delgado, direito.

Panícula com o nó inferior geralmente pubescente menos vezes glabrescente e medianamente desenvolvido, recurvada, fechada, um tanto rala.

Espigueta de articulação frágil, comprida, larga, espessa, verde no desenvolvimento, amarelo palha na maturação.

QUADRO V

Medições sobre 200 espiguetas

	Valores observados (mm)		$\bar{x}$	$s_{\bar{x}}$	c. v.
	Mínimo	Máximo			
Comprimento . .	8,0	9,2	8,61	0,23	2,73
Largura	3,1	3,9	3,54	0,15	4,09
Espessura . . .	2,0	2,5	2,24	0,09	4,10
Relação $\frac{\text{comp.}}{\text{larg.}}$ . .	2,21	2,77	2,43	0,10	4,10

Glumas a superior mais ou menos cuspidada, mais claras e brilhantes do que o resto da espigueta e com um pouco mais de um terço do comprimento desta.

Glumela inferior mútica com o dente apical da mesma coloração do que a espigueta, superfície pubescente principalmente na parte superior, nervura lateral mais ou menos equidistante da margem e da carena.

Estigmas brancos.

Cariopse mediana de comprimento, larga, espessa; pericarpo branco; albúmen de fractura vítrea quando bem maduro; embrião mediano; cavidade escutelar pouco escavada.

'Lusitano' — *Oriza sativa* L. ssp. *japonica* Kato var. *italica* Alef.
tipo *media* (Piacco) Vasc.

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QUADRO VI

Medições sobre 200 cariopses

	Valores observados (mm)		$\bar{x}$	$s_{\bar{x}}$	c. v.
	Mínimo	Máximo			
Comprimento . .	5,6	6,8	6,20	0,20	3,15
Largura. . . .	2,5	3,3	3,00	0,14	4,64
Espessura . . .	1,6	2,2	1,96	0,10	5,36
Relação $\frac{\text{comp.}}{\text{larg.}}$ . .	1,85	2,38	2,07	0,10	4,69

QUADRO VII

Outras características (*)

	'Allorio'	'A. da Terra'	'Lusitano'
Estatura	0,90	0,59	0,80
N.º de colmos por planta	18,7	16,3	15,9
N.º de panículas por planta . . .	15,4	13,2	14,7
N.º de espiguetas por panícula . .	44	39,2	58,4
N.º de espiguetas por planta . . .	680	539	849,9
Peso de 1.000 espiguetas (g). . .	29,610	29,073	29,76
Peso total (g)	16,70	15,95	22,4
Percentagem de brança (%) . . .	22,4	13,4	12,2

(*) Os números referentes às formas cultivadas 'Allorio' e 'Arroz da Terra', exceptuando a determinação « Peso de 1.000 grãos » (média de dois anos) baseiam-se em determinações de seis anos. Os valores correspondentes ao híbrido 'Lusitano' representam médias e determinações efectuadas em 1.000 plantas no ano de 1958, à excepção do « Peso de 1.000 grãos » que foi baseado em determinações de dois anos.

CICLO VEGETATIVO

'Allorio'	precoce
'Arroz da Terra'	precoce
'Lusitano'	precoce

Em relação a esta característica, o arroz 'Lusitano', num ensaio realizado na «Station Expérimentale Régionale de Ferme Blanche» na Argélia, evidenciou-se como o mais precoce entre 110 variedades de diferentes paízes como é referido no «Rapport du Conseill de L'Expérimentation et des Recherches Agronomiques pour 1953» publicado pelo Governo Geral da Argélia, em 1954.

Noutro ensaio realizado em Merle, no mesmo ano, num campo experimental de arroz do «Centre de Recherches Agronomiques du Midi-École National d'Agriculture de Montpellier, segundo R. Marie & J. Denoy (1954) o arroz 'Lusitano' foi também classificado muito precoce (139 dias).

PROVAS DE CAMPO

Apenas para orientação sobre o provável valor cultural deste híbrido referimos a produção unitária obtida num ensaio de produção realizado em 1958 no Posto Experimental do Vale do Sado.

Este ensaio, com 19 formas cultivadas, foi realizado em talhões de 40 m^2 com quatro repetições. Serviu de testemunha a forma cultivada 'Chinês'. Os resultados obtidos, que nos interessam registar, foram os seguintes:

QUADRO VIII

Forma cultivada	Produção Kg/ha	Valor relativo
Chinês . . .	6.250	100
Lusitano . .	6.019	96,3

ANÁLISES FÍSICA, TECNOLÓGICA E BROMATOLÓGICA

Análise em casca (%)

Grãos inteiros.	99,74
Trincas.	—
Impurezas	0,26
Total	100,00

Análise em película (%)

Grãos brancos.	83,49
» vermelhos	0,23
» verdes	13,23
» gessados	1,84
» amarelos	—
» avariados	0,41
» em casca	—
Total de grãos inteiros	99,20
Trincas brancas	0,49
» vermelhas	—
» avariadas.	0,05
Total de trincas	0,54
Cascas	—
Impurezas	0,26
Total geral	100,00

QUADRO IX

Humidade (%)

Arroz em casca	Arroz em película	Arroz em branco
12,97	13,67	13,57

QUADRO X

Peso por litro (g) *do arroz em casca*

Citómero Schopper		Citómetro Schmidt	
Com impurezas	Sem impurezas	Com impurezas	Sem impurezas
545,3	550,0	592,2	596,4

QUADRO XI

Peso por litro (g)

Citómetros		Película	3.º grau	2.º grau	1.º grau
Schopper	c/ trincas	783,2	824,6	830,4	836,5
	s/ trincas	783,3	820,5	824,2	833,6
Schmidt	c/ trincas	814,9	868,1	877,7	887,6
	s/ trincas	814,6	866,2	875,8	881,5

QUADRO XII

Peso e volume de 1.000 grãos

Casca		Película		3.º grau		2.º grau		1.º grau	
Peso g	Volume c c	Peso g	Volume c c	Peso g	Volume c c	Peso g	Volume c c	Peso g	Volume c c
29,76	27,5	24,78	18,0	21,39	15,5	21,06	14,8	20,94	14,6

QUADRO XIII

Volume de 100 g e densidade

Casca		Película		3.º grau		2.º grau		1.º grau	
Volume c c	Densidade	Volume c c	Densidade	Volume c c	Densidade	Volume c c	Densidade	Volume c c	Densidade
73,0	1,370	70,4	1,421	69,4	1,442	66,3	1,444	69,2	1,446

QUADRO XIV

Vitreosidade (%)

Totalmente vítreos	Até 1/4 gessados	Até 1/2 gessados	Até 3/4 gessados	+ de 3/4 gessados
25,34	36,01	30,66	6,66	1,33

QUADRO XV

Comportamento industrial (%)

	1.º grau	2.º grau	3.º grau
Grãos inteiros	61,49	65,39	68,83
Trincas	8,17	5,35	2,71
Rendimento industrial	69,66	70,74	71,54
Sêmea e germen	8,89	7,83	6,99
Farelo de casca	1,72	1,66	1,71
Casca	18,47	18,70	18,68
Impurezas	0,26	0,26	0,26
Perdas	1,00	0,81	0,82
Total	100,00	100,00	100,00

QUADRO XVI

Composição do arroz (%)

Intensidade de desgaste

	1.º grau	2.º grau	3.º grau
Grãos brancos	83,29	85,92	87,80
» vermelhos	0,12	0,14	0,17
» verdes	1,82	3,28	5,27
» gessados	2,78	2,83	2,72
» amarelos	—	—	—
» avariados	0,20	0,26	0,27
Total de grãos inteiros	88,21	92,43	96,23
Trincas de 1.ª	7,05	4,62	2,34
» de 2.ª	3,46	2,24	0,96
» de 3.ª	0,79	0,45	0,31
» de 4.ª	0,49	0,26	0,16
Total de trincas	11,79	7,57	3,77
Total geral	100,00	100,00	100,00

QUADRO XVII

Ensaios de cozedura

	Película	3.º grau	2.º grau	1.º grau
Grau de cozedura (m)	32,0	23,5	21,5	20,5
Quantidade de água absorvida (g). . . .	149,13	170,83	168,48	167,08
Volume de 100 g de arroz cru (c c) . . .	70,4	69,4	69,3	69,2
» do arroz depois de cozido (c c) . .	247,5	267,5	266,5	265,0
Aumento de volume com a cozedura (vezes).	3,5	3,8	3,9	3,9
Espolpamento	Normal	Normal	Normal	Normal

Pelos elementos laboratoriais obtidos, incluindo os biométricos, o arroz 'Lusitano' corresponde na Tabela em vigor ao tipo 'Gigante' de 2.ª, caracterizado por grãos do tipo médio, forma oblonga e de resistência regular à cozedura.

Segundo as características taxonómicas pode incluir-se na ssp. *japonica* KATO var. *italica* ALEF. tipo *media* (PIACCO) VASC.

O arroz 'Lusitano' está já descrito no « World Catalogue of Genetic Stocks, Rice Supplement N° 4 de Julho de 1954 », com o n.º 993.

SOMMAIRE

Dans ce travail on fait la description botanique de l'hybride 'Lusitano', obtenu par hybridation artificielle entre le riz 'Allorio' et 'Arroz da Terra', qui, eux, également, sont botaniquement décrits.

Par les caractéristiques taxonomiques, l'hybride 'Lusitano' peut être inclus dans la ssp. *japonica* KATO var. *italica* ALEF. tipo *media* (PIACCO) VASC.

On y présente aussi les résultats des différentes déterminations biométriques efféctuées, quelques observations en champ, ainsi que les analyses physique, chimique et technologique.

SUMMARY

In this work is made the botanical description of the hybrid 'Lusitano' obtained through the artificial hybridization of the 'Allorio' paddy and the 'Arroz da Terra' paddy, which are also botanically described. Because of its taxonomical characteristics

the hybrid 'Lusitano' can be included in the ssp. *japonica* KATO var. *italica* ALEF. tipo *media* (PIACCO) VASC.

Several biometrical determinations, some observations on the field and the physical, chemical and technological analyses are also reported.

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MECHANISMS OF SPECIES ISOLATION IN TUBEROUS *SOLANUM* [1]

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INTRODUCTION

THE interbreeding and interchange of genes between an individual or groups of individuals is limited or prevented by different ways in different cases. DOBZHANSKY (1937) proposed the expression « isolating mechanisms » for all mechanisms that prevent two individuals of the same or of different species to cross.

The isolating mechanisms are divided into two large classes, the geographical and physiological or reproductive.

Groups of individuals may be prevented from crossing by the simple fact that they live in different geographical regions. This type of isolation is believed by some investigators to be of great importance in the origin of species not only maintaining their distinction as populations, but also by the accumulations of great genetic differences.

Those populations may sometimes interchange genes indirectly, either through one population geographycally intermediate or by occasional migrants that overcome the barriers of distance.

In other cases, populations or individuals that live side by side can be maintained distinct if the interbreeding is prevented or limited by properties that are genetically controlled.

In the plant kingdom this isolating mechanism is typified by cross-incompatibility, lethality and sterility of the hybrids.

Cross-incompatibility is caused by the failure of the pollen of one individual to penetrate the stylar tissue of the other and so to reach the egg. This is not due to the sterility of the male and female organs but because they are together in a wrong combination (LEWIS, 1949).

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(1) This work was made at John Innes Horticultural Institution, Bayford_bury, Hertford, Herts. The data presented in this paper were submitted to the University of London as part of a M. Sc. thesis, and was supported by a grant from « The Calouste Gulbenkian Foundation, Lisbon ».

Sometimes two gametes of different species come in contact, fertilization takes place, but the life of the hybrid zygote may be arrested in a more or less advanced state and dies before it is mature (Sachet, 1948).

Finally the hybrid can reach the sexual maturity but fail to produce offspring, due either to cytological disturbances at meiosis or to the specific disharmonies between the parental complexes (Marks, 1954).

MATERIAL AND METHODS

Seeds and tubers of ten diploid species from the Commonwealth Potato Collection and one (*Solanum kurtzianum* Bitt.) sent by Dr. Toxopeus of Wageningen in the Potato Collection at the John Innes Horticultural Institution were used in the present study namely:

South American Species

Series ***Tuberosa***

Solanum kurtzianum Bitt. & Wittm.
Solanum vernei Bitt. & Wittm. (No. 5 = c. p. c. 2413), (No. 6 = c.p.c. 2414) and (No. 10 = c.p.c. 2487/5 × c.p.c. 2487/3)
Solanum simplicifolium Bitt. (c. p. c. 2486)
Solanum soukupii Hawkes (c.p.c. 539/12 × c.p.c. 530/11)
Solanum phureja Juz. & Buk. (c. p. c. 2211)

Mexican Species

Series ***Demissa***

Solanum verrucosum Schlecht. (No. 49 = c. p. c. 2514 s) and (No. 50 = c. p. c. 2515 s)

Series ***Polyadenia***

Solanum polyadenium Greenm. (c. p. c. 2408)

Series ***Cardiophylla***

Solanum cardiophyllum Lindl. (c.p.c. 2258 × c.p.c. 2269)
Solanum ehrenbergii (Bitt.) Rydb. (c. p. c. 2302) and (c. p. c. 2307)

Series ***Pinnatisecta***

Solanum jamesii Torr. (c. p. c. 1394) and (c. p. c. 1439)
Solanum pinnatisectum Dun. (c. p. c. 2291), (c. p. c. 2300) and (c. p.c. 2301)

All the especies were grown in the greenhouses where the pollinations were made.

Emmascullations of the self-compatible and some dubious self-incompatible species were made before the flowers opened and the pollinations were made on the following day. The compatibility was determined by the examination of pollen tube growth in the style. After pollination the flowers were cut, transferred to small bottles of water and placed in an incubator at 25° C. Forty eight hours later the styles were removed and stained in acid fuchsin and light green (Darlington & La Cour, 1947) overnight at a temperature of 60° C.

RESULTS

The eleven species of *Solanum* were selfed and crossed in all combinations possible (Fig. 1). With the exception of *S. verrucosum*, they were all self-incompatible species. In spite of its self-incompatibility one berry with 19 seeds was obtained from a self-pollination in *S. simplicifolium*. *S. polyadenium* has been considered a self-compatible species (Clark, 1927 and Choudhuri, 1944) but in our material was self-incompatible. The same fact was observed by Propach (1940).

The growth of pollen tubes in interspecific crosses among the eleven species is given in the Fig. 2.

The Fig. 2 shows that four groups can be distinctly formed. The first group is formed by the species of the series *Tuberosa*. These are either fully cross-compatible or « semi-compatible » [1] between themselves and incompatible with all Mexican species.

The second group is formed by the species *S. verrucosum* of series *Demissa* this is compatible with pollen of all self-incompatible species either from Mexico or South America, with the exception of *S. polyadenium*.

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(1) When the pollen tubes are found at the end of the style 48 hours after pollination, while the compatibles are in the ovary at the same time.

A third group is formed by *S. polyadenium* of the series *Polyadenia*, and by the two species of the series *Cardiophylla*. These were incompatible with all the species belonging to the

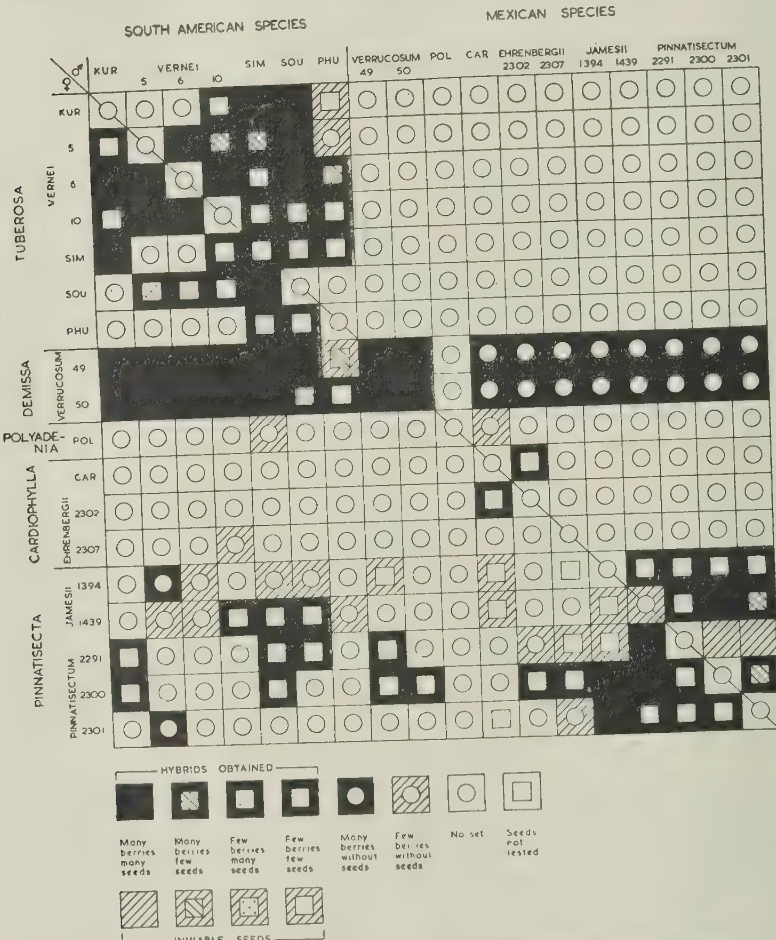

Fig. 1 — The fertility of interspecific crosses between eleven species of tuber-bearing *Solanum*.

other series. *S. polyadenium* shows two exceptions, with the pollen of *S. kurtzianum* and *S. simplicifolium*.

Finally a fourth group is formed by the species of series *Pinnatisecta*. These are in general «semi-compatible» with the

species of the other series, with the exception of *S. verrucosum* and *S. polyadenium*, which produce pollen that is incompatible on the other series. This division into four different mating groups

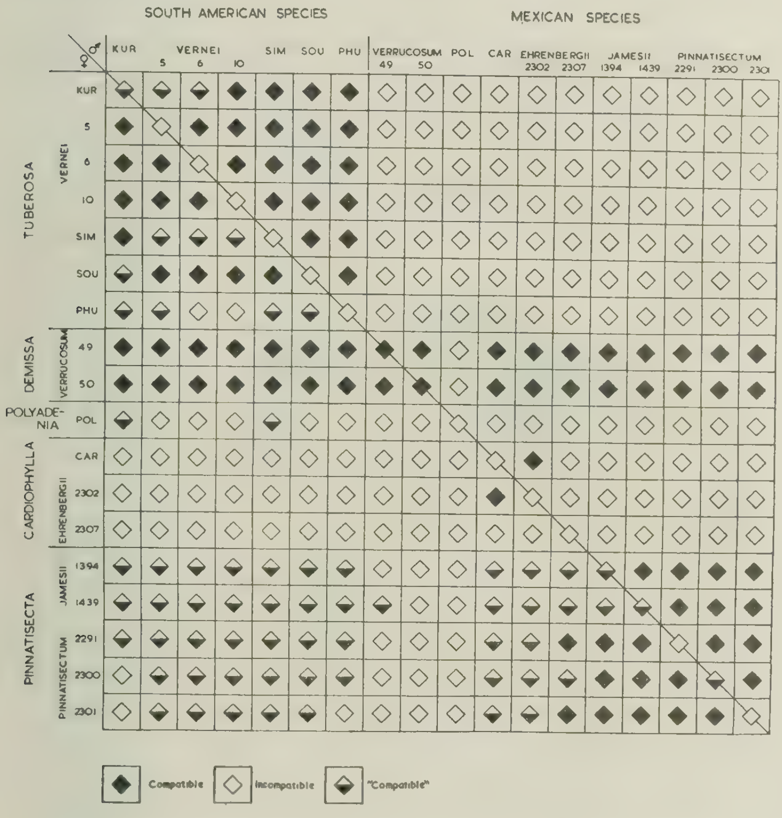

Fig. 2 — The pollen tube growth in crosses between eleven species of tuber-bearing *Solanum* « compatible » = « semi-compatible » in the text.

is in general agreement with the taxonomic classification into the different series (Fig. 2).

Another interesting result is the behaviour of the self-compatible species *S. verrucosum*. In spite of its compatibility with pollen of both Mexican and South American self-incompatible species it produces berries with seeds when crossed, only with

the species of the series *Tuberosa;* with all the others it gives empty berries (Fig. 1). This result, also agree with the taxonomy. The series *Demissa*, in which *S. verrucosum* is now placed, was created by BUKASOV only in 1938 and had been previously placed in the series *Tuberosa* by RYDBERG (1924, *ex* HAWKES, 1944). *S. verrucosum* is considered a probably ancestral form of all *Demissa* species and constitutes a link with the series *Tuberosa* (HAWKES, 1956).

S. verrucosum, although it is compatible with all self-incompatible species when used as male, as expected, since unilateral incompatibility of the type $S_I X S_C$ is the rule in flowering plants (LEWIS & CROWE, 1958).

It has been found in species of the families *Solanaceae* and *Scrophulariaceae* that pollen of self-incompatible species are not inhibited in the styles of the other incompatible species; i. e. a cross, $S_I X S_I$ is cross-compatible. But when we crossed the self-incompatible species of the series *Tuberosa* with the self-incompatible species of the series *Cardiophylla* we found that the pollen tubes were inhibited in the styles independently of the way of the cross, i. e. $S_I X S_I$ in our material was cross-incompatible.

S. polyadenium behaves in an exceptional way in several respects. It is self-incompatible and yet its pollen is inhibited in the style of all other species irrespectively of whether they are S_I or S_C. Furthermore when crossed with the self-compatible *S. verrucosum* it is incompatible both as male and female.

S. jamesii and *S. pinnatisectum* the two « self-incompatible » Mexican species of the series *Pinnatisecta*, when used as females set berries, in general, either with Mexican or South American species, but in a great number of cases the berries were empty. As male parents they were compatible only when crossed together.

Crosses within South American species Series Tuberosa

As shown in Fig. 2 *S. kurtzianum* is compatible with pollen of *S. simplicifolium*, *S. soukupii*, *S. vernei* (clone 10) and *S. phureja*, but seems to have a « semi-compatibility » with its own pollen and pollen of *S. vernei* (clones 5 and 6) since it is possible to find some pollen tubes growing at the base of the style after 48 hours of pollination in constrast with the compatible ones, that are in

the ovary at the same time, or with the incompatibles that are stopped just after the stigma.

Successfull crosses in both ways were obtained with *S. kurtzianum* and either with *S. simplicifolium* or *S. vernei* (clone 10),

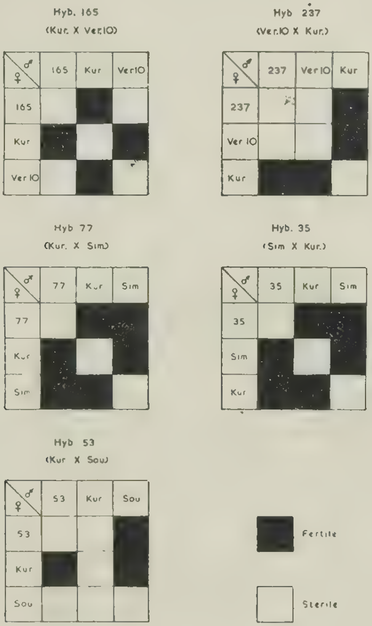

Fig. 3 — Results of the backcrosses, with both parents of the hybrids:

S. kurtzianum × *S. vernei*
S. kurtzianum × *S. simplicifolium*
S. kurtzianum × *S. soukupii*

Fertile = berries with seeds
Sterile = no set

but only in one way as female, when crossed with *S. soukupii.*

The hybrid seed of the cross *S. kurtzianum* × *S. phureja* did not germinate.

The results of the self- and cross-compatibility of these hybrids with the parental species are summarized in Fig. 3.

The morphological characteristics of the hybrids were intermediate in general, between the parental species. Nevertheless the F_1 plants from the cross between *S. kurtzianum* and *S. simplicifo-*

lium, in both ways all had the compound leaves of *S. kurtzianum*. Choudhuri (1944) observed the same fact, when he crossed *S. simplicifolium* with *S. rybinii* which has a compound leaf. The flowers were larger than the flowers of the parental species, with white rotate corolla slightly stained violet on the lobes as in *S. kurtzianum*.

The hybrids between *S. kurtzianum* and *S. vernei* (clone 10) had the morphological caracteristics intermediate between the parental species, except the flowers which had a violet corolla like *S. vernei*.

The F_1 plants from the cross between *S. kurtzianum* and *S. soukupii* resembled *S. soukupii* in the colour and shape of the leaf and size and shape of the corolla and calyx of the flowers.

The three clones of *S. vernei* were cross-compatible when pollinated with pollen of all the species of the series *Tuberosa* and incompatible with their own pollen (Fig. 2). The two clones (5 and 6) were successfully crossed, only in one-way as females, with *S. kurtzianum*, *S. simplicifolium* and *S. phureja* and in both ways with *S. soukupii*. The clone 5, however produced only one berry but devoid of seeds, when pollinated with pollen of *S. phureja*. The results of the self- and cross-compatility of the hybrids involving the three clones of *S. vernei* are summarized in the Figs. 4, 5 and 6. The hybrids between *S. vernei* (clone 5 and 6) and *S. kurtzianum* were like the hybrids between *S. vernei* (clone 10) and *S. kurtzianum*, already described.

The F_1 plants from the cross between *S. vernei* (clones 5 and 6) and *S. simplicifolium* were all with the compound leaf of the female parent, but with a smaller number of leaflets but larger and with the shape of the simple leaf of *S. simplicifolium*. The flowers were light blue violet with a larger corolla than either parent.

The progeny from the crosses of *S. vernei* (clone 10) and *S. simplicifolium* showed different morphological characteristics according to the way of the cross. When *S. vernei* was used as female, the hybrids were like the hybrids described for the clones 5 and 6. But when we used *S. vernei* (clone 10) as male, we obtained only one plant that showed the simple leaf and the white flowers of *S. simplicifolium*. This plant, however we suppose is not an hybrid but a product of self-pollination, not only because of its morphological characteristics bus also because *S. simplici-*

folium did not cross with the other clones of *S. vernei* when used as female.

The F_1 plants from the crosses between the three clones of *S. vernei* and *S. soukupii* were uniform in morphological characteristics and intermediate between the parental species.

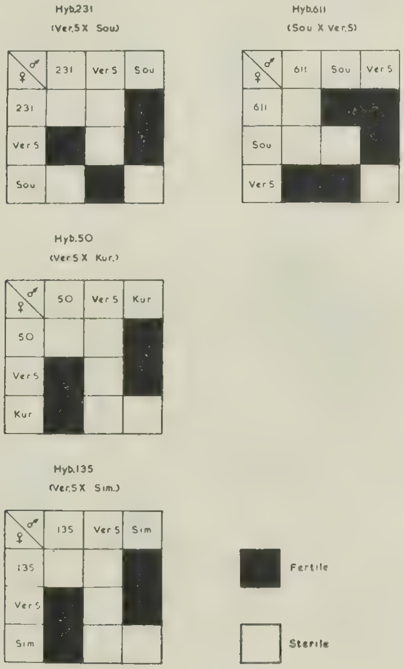

Fig. 4 — Results of the backcrosses with the parental species of the hybrids:

S. vernei (clone 5) × *S. soukupii*
S. vernei (clone 5) × *S. simplicifolium*
S. vernei (clone 5) × *S. kurtzianum*

Fertile berries with seeds
Sterile = no set

The hybrids plants from the crosses between *S. vernei* (clones 5 and 6) and *S. phureja*, were intermediate, between the parental species, but the tubers have the short rest period of the tubers of *S. phureja*. The same characteristics was observed by PRAKKEN & SWAMINATHAN (1952) when they crossed *S. phureja* with *S. tuberosum*.

Our clone of *S. simplicifolium* showed cross-compatibility

with the pollen of *S. kurtzianum*, *S. soukupii* and *S. phureja*, « semi-compatibility » with the three clones of *S. vernei*, and incompatibility with its own pollen.

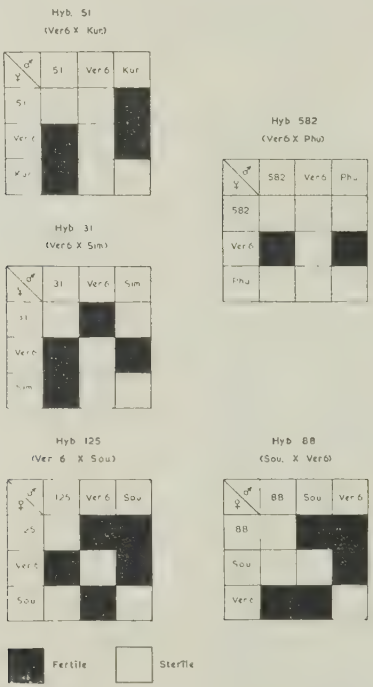

Fig. 5 — Results of the backrosses with both parents of the hybrids:

S. vernei (clone 6) × *S. kurtzianum*
S. vernei (clone 6) × *S. simplicifolium*
S. vernei (clone 6) × *S. soukupii*
S. vernei (clone 6) × *S. phureja*

Fertile = berries with seeds
Sterile = no set

No berries were obtained from the crosses between *S. simplicifolium* and two of the three clones of *S. vernei*.

The hybrid plants from the cross *S. simplicifolium* × *S. soukupii* possessed intermediate characteristics between the parental species and were very uniform.

The F_1 plants from the crosses between *S. simplicifolium* and *S. phureja* were very variable with differences in the habit of the

plants, and in colour, size and form of leaf, sometimes resembling more the species *S. phureja*, sometimes *S. simplicifolium*. The flowers were larger than the flowers of the parental species with

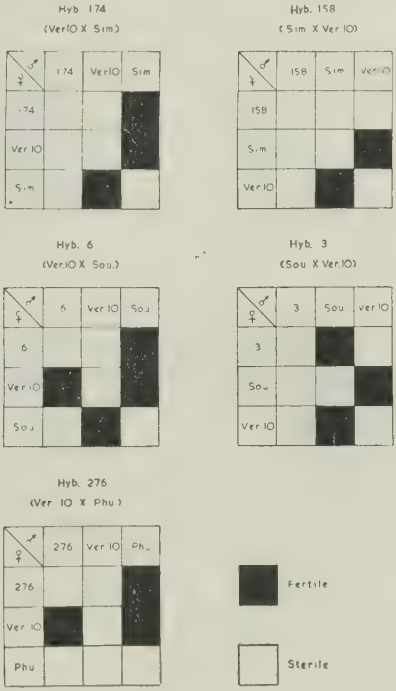

Fig. 6 — Results of the backcrosses with the parental species of the hybrids:

S. vernei (clone 10) × *S. simplicifolium*
S. vernei (clone 10) × *S. soukupii*
S. vernei (clone 10) × *S. phureja*

Fertile = berries with seeds
Sterile = no set

a light blue violet corolla, in spite of both parents having white flowers.

The tubers showed the short rest period observed in the previous crosses involving *S. phureja*.

S. soukupii was cross-compatible with all species of the series *Tuberosa* tested, with the exception of *S. kurtzianum* with which it showed « semi-compatibility ». When crossed with *S. phureja*, it was not possible, also to obtain any berries.

S. phureja behaved differently from the other species of the same series. Its pollen was compatible in the style of all of them, its own style was «semi-compatible» with pollen of *S. kurtzianum*,

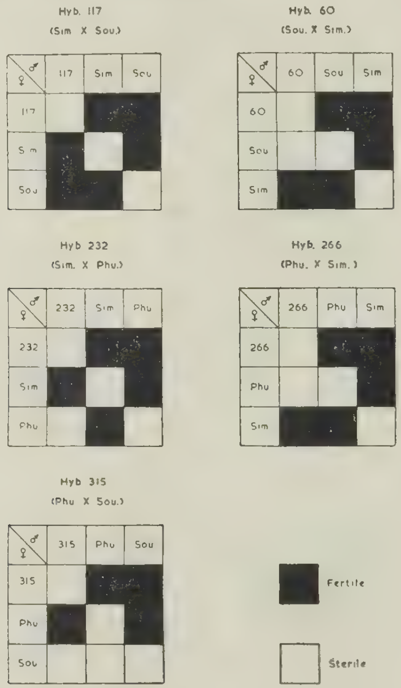

Fig. 7 — Results of the backcrosses with both parents of the hybrids:

S. simplicifolium × *S. soukupii*
S. simplicifolium × *S. phureja*
S. phureja × *S. soukupii*

Fertile = berries with seeds
Sterile = no set

S. soukupii, *S. vernei* (clone 10) and *S. simplicifolium* and fully incompatible with pollen of *S. vernei* (clones 6 and 10).

Successfull crosses were obtained in both ways with *S. simplicifolium*, in one way as male with *S. vernei* (clones 6 and 10), as already described, and in one way also, as female with *S. soukupii*.

The F_1 plants from the cross *S. phureja* × *S. soukupii* varied

a little but had morphological characteristics of both parents. The flowers were large, with light blue violet corolla, with the shape of the flowers of *S. phureja*. The results of the self- and cross-compatibility involving *S. simplicifolium*, *S. soukupii* and *S. phureja*, not yet represented in the other Figs., are summarized in the Fig. 7.

Crosses between Mexican and South American species

As it is shown in the Fig. 2 all the pollen of the species of the series *Tuberosa* were compatible in the style of *S. verrucosum* (clone 49 and 50) series *Demissa*, and that hybrids of all, were obtained with the exception of the cross *S. verrucosum* (clone 49) $\times$ *S. phureja* because the seeds did not germinate.

All the hybrids had the general habit of the male parent but with intermediate characteristics, in leaf and flowers. The characteristics of the leaves and flowers of the parental species and the hybrids are represented in the Plates (I, II, III, IV and V). The hybrids from these crosses were self-incompatible as we expected, since this is the rule in the gametophytic system (Lewis & Crowe, 1958). There was one exception: one plant (14[1]) from the cross *S. verrucosum* (clone 50) $\times$ *S. kurtzianum*, was self-compatible.

In hybrids between a self-compatible species $S_C S_C$, which shows unilateral incompatibility and a self-incompatible $S_I S_I$ all the F_1 plants should be of the constitution $S_C S_I$ and segregate two types of pollen S_C and S_I that are both inhibited, S_C by the presence of S_I in the style and S_I because S_I is also present. In the Fig. 8 are summarized the results of selfing and crossing with both parental species. One remarkable feature was the consistency of the results: self-incompatibility of the hybrids; cross-incompatibility of the hybrids with the female parent; cross-compatibility with the male parent and, cross-incompatibility of the pollen of the F_1 hybrids on the two parents. We found one exception in the case of *S. vernei* (clone 5 and 6) and *S. phureja*.

If we assume that *S. verrucosum* is of the constitution $S_C S_C$ and the self-incompatible species are of the constitution $S_x S_y$, we have two types of plants in F_1, $S_C S_x$ and $S_C S_y$, both self-incompatible with the pollen of *S. verrucosum*, S_C by the presence of S_x or S_y in the style and cross-compatible with the male parent

that segregate S_x and S_y pollen and pollen S_x grows down in a style $S_C S_y$ and S_y in a style $S_C S_x$.

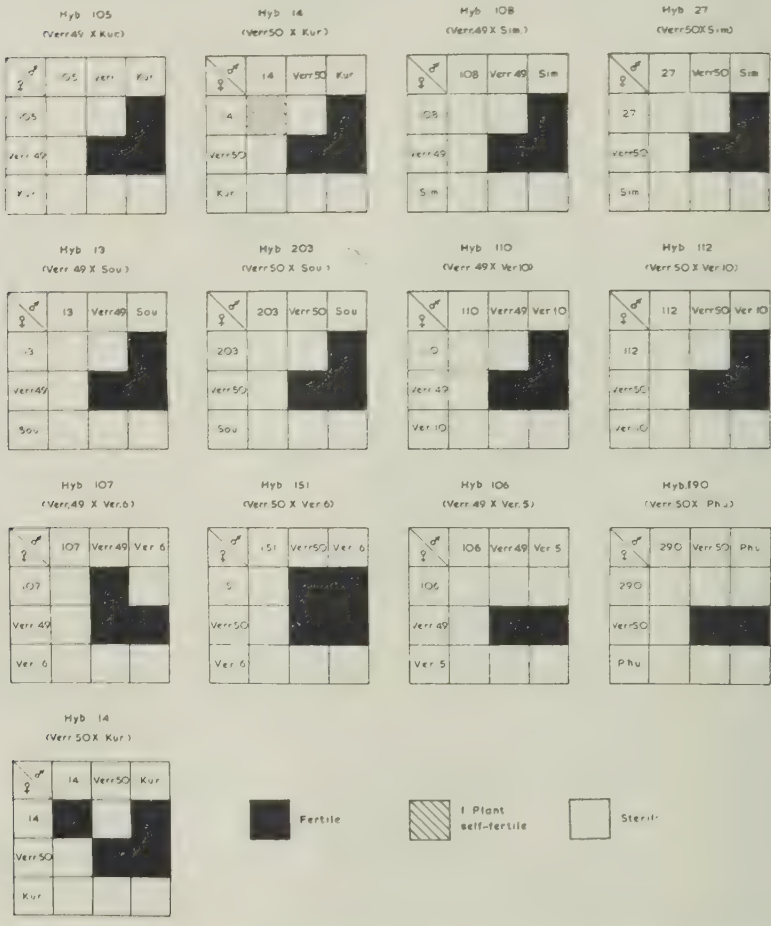

Fig. 8 — Results of the backcrosses with both parents of the hybrids between the lines of *S. verrucosum* with the species of the series *Tuberosa*.

Fertile = berries with seeds
Sterile = no set

The male parent $S_x S_y$ as expected was cross-incompatible with the progeny, but *S. verrucosum* should be cross-compatible with the F_1 because pollen S_C, S_x or S_y should grow in its style

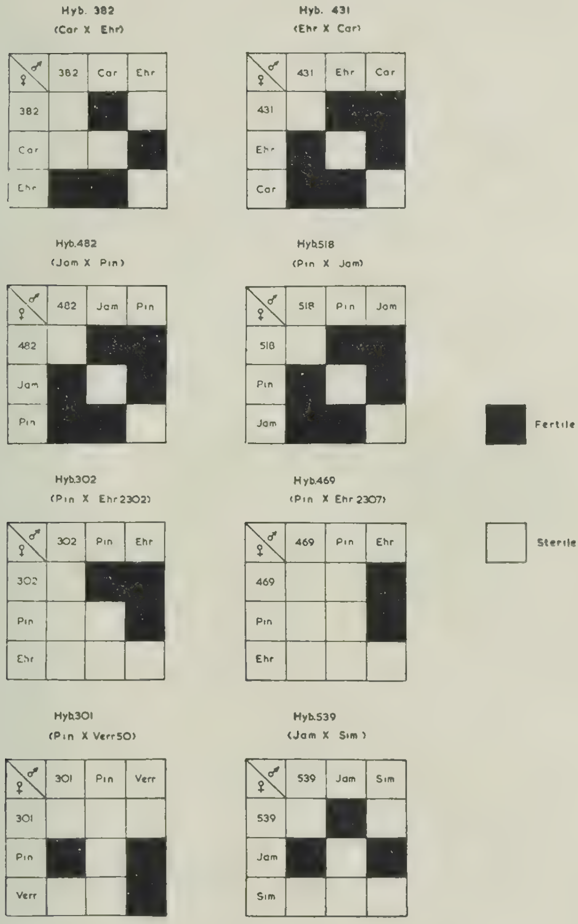

Fig. 9 — Results of the backcrosses with both parents of the hybrids:

S. cardiophyllum × *S. ehrenbergii*
S. jamesii × *S. pinnatisectum*
S. pinnatisectum × *S. ehrenbergii*
S. pinnatisectum × *S. verrucosum*
S. jamesii × *S. simplicifolium*

Fertile — berries with seeds
Sterile = no set

but was in our crosses, cross-sterile. The cross-sterility can be due to the sterility of the pollen of the hybrids, but as represented in Fig. 8 when we used the pollen of the self-compatible plant (14^1) the result was the same.

S. polyadenium was strongly incompatible with its own pollen and pollen of *S. vernei* and *S. soukupii* so strongly that a great majority of the pollen grains were not able to germinate on the stigma. With the pollen of *S. phureja* it showed the usual incompatibility in the style as observed in the other species of *Solanum*, and when pollinated with pollen of *S. kurtzianum* and *S. simplicifolium* it presented the «semi-compatibility» since the pollen was able to grow down to the base of the style after 48 hours of pollination. Only one berry was obtained from one cross between *S. polyadenium* × *S. simplicifolium* but it did not contain seed.

The species *S. cardiophyllum* and *S. ehrenbergii* were completely incompatible with all species of series *Tuberosa*.

S. jamesii and *S. pinnatisectum* of the series *Pinnatisecta* showed a remarkable behaviour. The pollen of all the species of the series *Tuberosa* were able in general to grow down to the base of the style of those two species, although the reciprocals were incompatible.

Some hybrids were obtained from the crosses between *S. jamesii* (clone 1439) and *S. vernei* (clone 10), *S. simplicifolium* and *S. soukupii* and from crosses between *S. pinnatisectum* (clones 2291 and 2300), and *S. kurtzianum, S. simplicifolium* and *S. soukupii.* All the hybrids were identical showing the morphological characteristics of the mother parents, but they were weaker and gave very few flowers. Only from one hybrid between *S. jamesii* (clone 1439) × *S. simplicifolium* we could try the crossability with the parental species and the results are in the Fig. 9 (hyb. 539).

An important feature to note is that in general after every cross between the species of series *Pinnatisecta* and of series *Tuberosa* we obtained berries empty of seeds.

Crosses within Mexican species

S. verrucosum was comp tible with pollen of all self-incompatible species of the series *Cardiophylla* and *Pinnatisecta*. Nevertheless although berries were set after every cross, no seeds were found inside the berries formed and so no hybrids were obtained.

With pollen of *S. polyadenium*, *S. verrucosum* showed a strong incompatibility, the pollen tubes were not able to penetrate the style, and in the reciprocal cross the incompatibility was stronger since the pollen was not able to germinate in the stigma. All the other species were incompatible with *S. polyadenium*.

S. cardiophyllum was cross-compatible, in both ways, only with *S. ehrenbergii* (clone 2302). The hybrids obtained had the morphological characteristics of both parent. The results of the self- and cross-compatibility with both parents are summarized in the Fig. 9.

S. jamesii and *S. pinnatisectum* were cross-compatible and some hybrids were obtained, giving when backcrossed with the parental species, the straighforward results expected with gametophytic system with one gene with multiple alleles.

Some hybrids were obtained from the cross *S. pinnatisectum* × *S. ehrenbergii* (clone 2307), and although as showed in Fig. 2, *S. verrucosum* was not compatible with *S. pinnatisectum*, some « hybrids » were obtained from this cross.

A very remarkable feature of the hybrids involving *S. pinnatisectum* with species from the other series, was that all possessed the maternal morphological characteristics as already said, like flowers and leaves. However the leaves of the hybrids have showed one or two pairs of leaflets less than the leaves of *S. pinnatisectum*.

DISCUSSION

Looking upon the results of the interspecific crosses between the eleven species studied, we find that the results show some deviations from the results given by some of the previous works made in species of the same family.

Genetics of incompatibility has been well studied in the *Solanaceae* family and the homomorphic gametophytic system with one « S » locus with multiple alleles, was first described by East & Mangelsdorf (1952) in *Nicotiana sanderae*. Some years later Harland & Atteck (1933), working with different species of the genus *Petunia*, and Pal & Pushkarnath (1942) and Pushkarnath (1942 and 1945) with some species of the genus *Solanum*, of the series *Commersoniana*, *S. caldasii*, *S. subtilius*, *S. chacoense* and *S. jujuiense* found the same oppositional system of incompatibility.

The growth of the pollen tubes of the interspecific crosses

given in the Fig. 2 are classified in three types, *compatible* when they were seen in the ovary after 48 hours after pollination, *incompatible* when they were stopped at the beggining of the style and *« semi-compatible »* when they were at the end of the style after the same period of time. When two species of the same series showed full compatibility in both ways as the case of the species of the series *Tuberosa, S. kurtzianum* and *S. simplicifolium*, and in the series *Pinnatisecta* between the species *S. jamesii* and *S. pinnatisectum* the results obtained of the backcrosses of their hybrids with the parental species fit well into the gametophytic incompatibility system with one « S » locus with multiple alleles. But when two species show full-compatibility in one-way of the cross and « semi-incompatibility » or incompatibility in the other as it is frequently found between the self-incompatible species of the series *Tuberosa*, hybrids were obtained only in the way that showed full compatibility. This was the case of the species *S. soukupii* which was cross-fertile with *S. kurtzianum*, only when used as male, the case of *S. kurtzianum* and *S. simplicifolium*, which were only fertile, as males when crossed with the clones 5 and 6 of *S. vernei* and of *S. phureja* when crossed with the clones 6 and 10 also of *S. vernei*.

The results obtained in the backcrosses with the parental species of these one-way hybrids do not fit with the gametophytic system with only one « S » locus. However, we found that other results of the backcrosses of hybrids obtained in both ways between other species of the same series, do not fit also in the gametophytic system with « S » locus.

One-way fertility was also found to occur between species of the series *Tuberosa* by Emme (1936) when he crossed *S. aracc-papa* and *S. bukasovii*. Choudhuri (1944) found the same behaviour, when he pollinated *S. rybinii* with pollen of *S. kesselbrenneri* obtaining full fertility and sterility in the reciprocal cross. However if *S. rybinii* is used as female parent and *S. parodii*, a species of the series *Commersoniana*, as male, the cross is sterile whereas the reciprocal is fertile. Later Pushkarnath (1952) working with *S. aracc-papa* found also one-way fertility, when he crossed this species with some species of the series *Commersoniana*. He found that *S. aracc-papa* never sets berries when used as female parent with all the species tested, and that it was cross-fertile with some of them when used as male. He studied the cross *S. subtilius* ×

S. aracc-papa and explained the results satisfactorily on the assumption that an additional factor « R » exists in *S. aracc-papa* which when present in the style in homozygous or heterozigous condition, prevents fertilization with pollen carrying « S » alleles. Also in 1953, PUSHKARNATH studing the F_1 of the cross *S. ribinii* $\times$ *S. subtilius* found results that he only could explain « by the presence of more than one independent system of genes controlling the crossability » and said also « The crossability relationships between two independent systems do not and are not expected to follow the results as would be secured from a series of alleles belonging to a single gene ».

CARSON & HOWARD (1942) reported that although the progeny from a cross between two varieties of *S. rybinii* was cross-compatible with both parents, they were not able to find that the F_1 plants could be classified in only four mating groups as would be expected in the gametophytic system with one « S » locus. BAINS (1951) working with the same varieties of *S. rybinii* reported that in addtion to the four groups expected, three plants were found that formed three separated groups.

Finally PANDEY (1957), studying the progenies of the reciprocal crosses between two plants of *Physalis ixocarpa* BROT., also a species of the family *Solanaceae* found different results according to the way of the cross and to explain the results obtained, he assumed that in *Physalis*, the genetic control is due to two independently segregating loci, each with a series of multiple alleles, and so two systems of incompatibility could be operating in the *Solanaceae* family.

Thus it appears from these last works that the mechanism of incompatibility in *Solanaceae* is more complicated than that described by EAST & MANGELSDORF (1925) in *Nicotiana* and in genus *Solanum* by PUSHKARNATH (1942 and 1945).

However, all those authors, did not make any reference to the pollen tube growth and we do not know if the results obtained were due to the factors of incompatibility or due to other factors causing zygotic sterility.

It is clear from the study of the Figs. 1 and 2 that the « semi-compatibility » found between some of the species of the series *Tuberosa*, results in general in one-way fertility.

This one-way fertility is not due to lack of pollen tube growth in the style but due to the failure of the pollen tubes to penetrate

the ovary or the microphyle, or if they reach the egg to the failure of fertilization, possibly due to incompatibility between the two gametes. Thus it seems that a genetic factor is present independently of the «S» locus, possibly with a series of alleles, that can be acting sometimes in the ovary or in the egg and sometimes in the pollen and that prevent fertilization.

We think, due to the similarity of the results, between our one-way crosses *S. kurtzianum* × *S. soukupii* (hyb. 53, Fig. 3) and *S. vernei* (clone 10) × *S. phureja* (hyb. 276, Fig. 6) with the results of the cross *S. subtilius* × *S. aracc-papa*, studied by PUSHKARNATH (1952) that a similar factor is present in both cases, and that he explained by an additional factor «R», that prevent fertilization, with pollen carrying «S» alleles, and that in our case is only active with certain «S» alleles.

Thus it appears that in the species of the series *Tuberosa* two factors of incompatibility are operating one the «S» locus in the style and another, that we named as PUSHKARNATH (1952) factor «R», that is only active when the pollen tube reach the ovary. These two independent genes must be the responsible by the unexpected results of the crossability found by the different authors when species af the series *Tuberosa* are involved.

The self-compatible species *S. verrucosum* although cross-compatible with the species of the series *Cardiophylla* and *Pinnatisecta*, fails to produce berries with seeds when crossed with them, possibly due to some genetic factor that in this case is operating after fertilization.

The species of the series *Pinnatisecta* have behaved as self-«compatible» species and were in general compatible with all self-incompatible species tested when used as females. However very few hybrids were abtained, because the production of empty berries and failure of seeds germination.

SUMMARY

Studies of cross-compatibility and pollen tube growth were made between the eleven species of tuberous *Solanum*, distributed among five different series. All species were self-incompatible, with the exception of *S. verrucosum*, that was self-compatible.

The species were selfed and crossed in all combinations possible, in order not only to obtain hybrids, but also to study

the pollen tube growth. Some hybrids were obtained and their morphological characteristics described, and compared with the morphological characteristics of the parental species.

The hybrids were backcrossed with both parents, to study their crossability.

The cross-compatibility in the species of the same series, showed a very regular behaviour that is in agreement with the taxonomic division.

The S_C species *S. verrucosum* was cross-compatible, only in one-way as female with pollen of all self-incompatible species, but only gave progenie with the species of the series *Tuberosa*. This result is in agreement also with the taxonomy since *S. verrucosum* is a species closely related to the species of the series *Tuberosa*.

One-way fertility was frequently found between some of the self-incompatible species of the series *Tuberosa* and another results that showed deviations from expectations with a gametophytic system with one « S » locus with multiple alleles.

One factor « R » is postulated that is responsible by the deviations of the results expected.

The species *S. jamesii* and *S. pinnatisectum* were in general compatible with pollen of all self-incompatible species but in a great majority of the cases, the berries formed had no seeds.

SUMÁRIO

Efectuaram-se estudos de compatibilidade e crescimento de tubos polínicos entre onze espécies de *Solanum* produtoras de tubérculos, pertencentes a cinco séries diferentes. Todas as espécies se mostraram auto-incompatíveis, com excepção da espécie *S. verrucosum*.

As diferentes espécies foram auto-polinizadas e cruzadas em todas as combinações possíveis, com o fim não só de obter híbridos, mas também de se estudar o crescimento dos tubos polínicos (Figs. 1 e 2).

Descrevem-se os híbridos e confrontam-se as suas características morfológicas com as dos progenitores.

Foram também estudadas as possibilidades de cruzamento retrógado entre os híbridos e os progenitores.

A compatibilidade entre as espécies da mesma série mostrou

um comportamento regular, que está de acordo com a divisão taxonómica.

A espécie *S. verrucosum* foi compatível só num sentido, como progenitor feminino, com pólen de todas as espécies auto-incompatíveis, mas deu descendência ùnicamente com as espécies da série *Tuberosa*. Este resultado está também de acordo com a taxonomia pois *S. verrucosum* é uma espécie estreitamente aparentada com as espécies da série *Tuberosa*.

A fertilidade unilateral, encontrada frequentemente em cruzamentos entre espécies da série *Tuberosa*, e outros resultados que se afastaram dos que seriam de esperar no sistema gametofítico de incompatibilidade com um locus «S» com alelos múltiplos, levaram a admitir a existência dum novo factor «R» responsável pelos desvios observados.

As espécies *S. jamesii* e *S. pinnatisectum* foram duma maneira geral compatíveis com o pólen de todas as espécies auto-incompatíveis mas na maioria dos casos, os frutos formados não apresentavam sementes.

ACKNOWLEDGEMENT

I wish to express my thanks to Professor D. Lewis, F. R. S. for his many useful suggestions in the interpretation of the data. I am deeply indebted to Dr. K. S. Dodds, Director of John Innes Horticultural Institution, for suggesting and for facilities to carry out this study. I should like to acknowledge Mr. G. E. Marks for his help throughout the experiments and to Mr. L. S. Clark for his photographic work.

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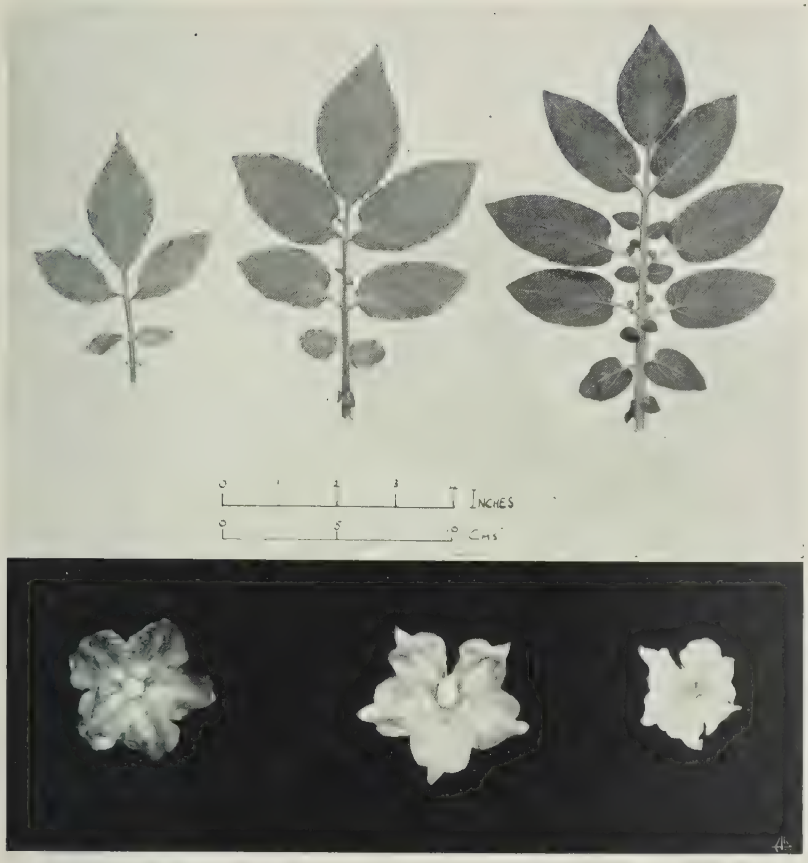
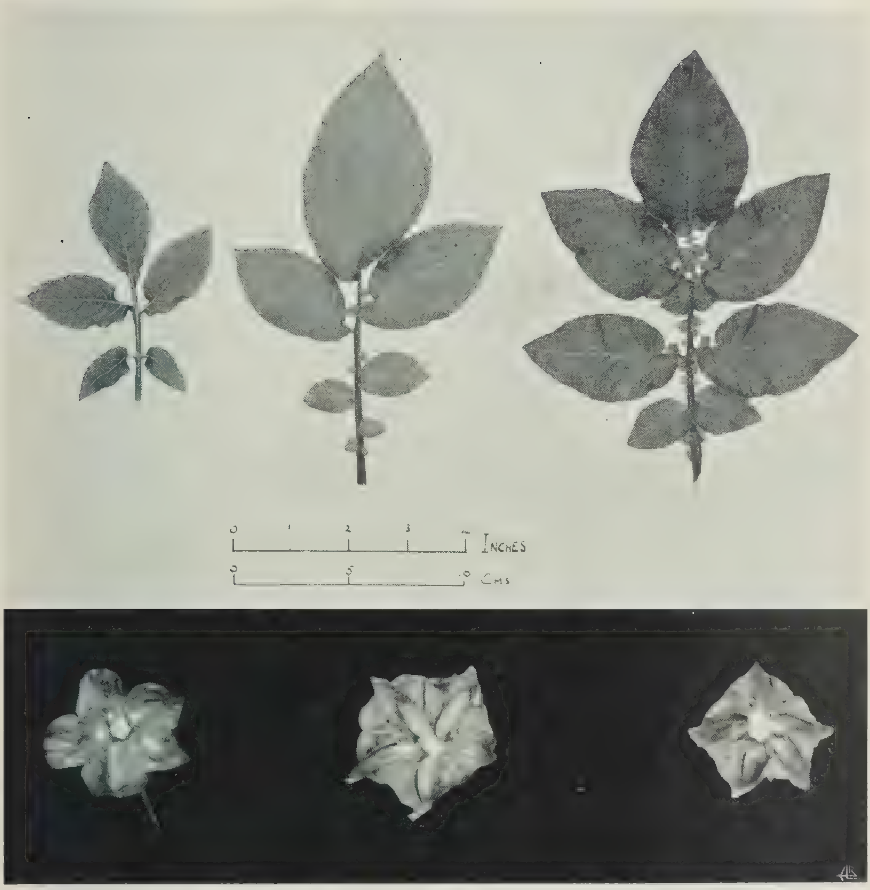
PLATE I

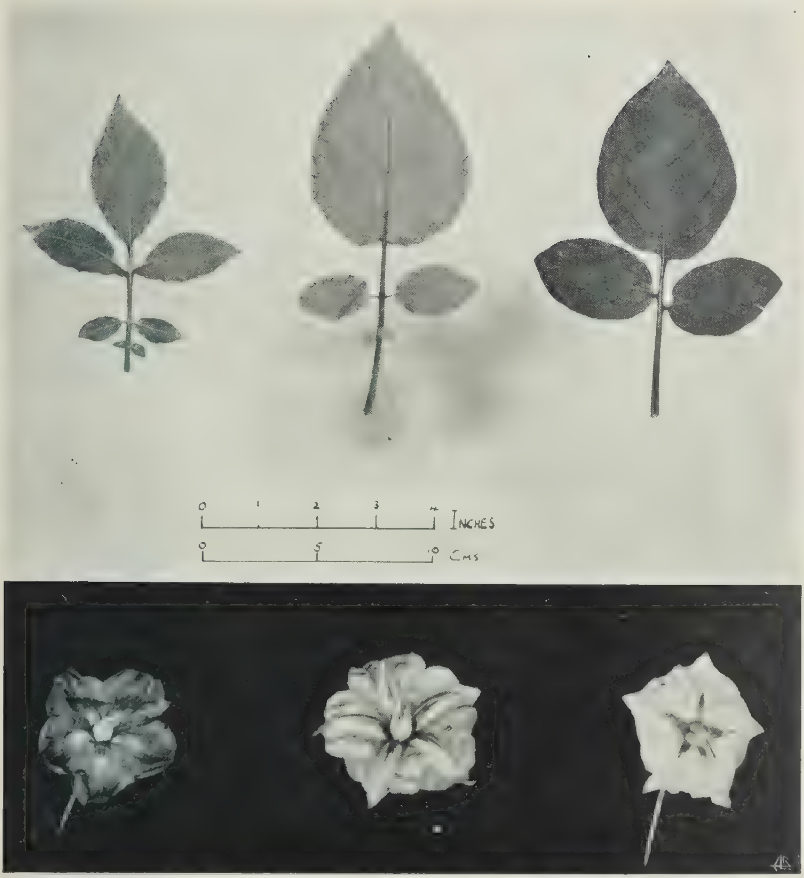


The morphological characteristics of leaves and flowers of the species *S. verrucosum* (in the left) *S. kurtzianum* (in the right) and of the hybrid *S. verrucosum* × *S. kurtzianum* (in the centre).

PLATE II



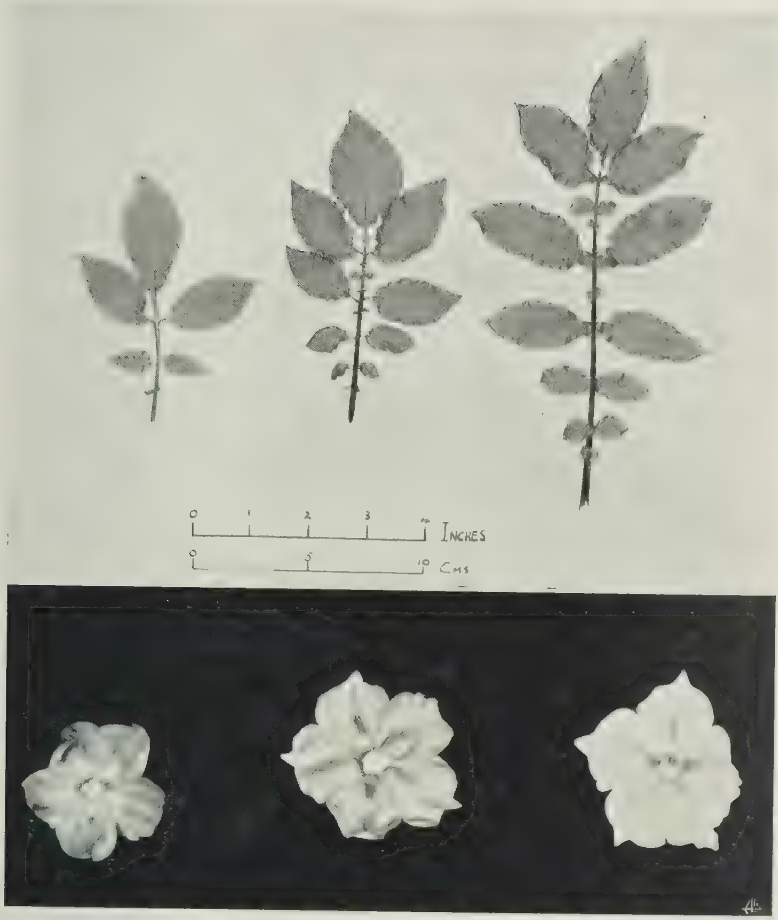
The morphological characteristics of leaves and flowers of the species *S. verrucosum* (in the left) *S. vernei* (in the right) and of the hybrid *S. verrucosum* × *S. vernei* (in the centre).



The morphological characteristics of leaves and flowers of the species *S. verrucosum* (in the left) *S. simplicifolium* (in the right) and of the hybrid *S. verrucosum* × *S. simplicifolium* (in the centre).

PLATE IV

The morphological characteristics of leaves and flowers of the species *S. verrucosum* (in the left) *S. soukupii* (in the right) and of the hybrid *S. verrucosum* × *S. soukupii* (in the centre).



The morphological characteristics of leaves and flowers of the species *S. verrucosum* (in the left) *S. phureja* (in the right) and of the hybrid *S. verrucosum* × *S. phureja* (in the centre).

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EXPERIMENTS ON CONTROL OF THE PESTS OF THE YELLOW LUPIN (*LUPINUS LUTEUS* L.)

I — INSECTICIDES

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INTRODUCTION

THE region south of the river Tagus has soils predominantly poor, sandy, extremely acid and deficient in organic matter. In such a region, a crop like the yellow lupin (*Lupinus luteus* L.) may be considered as providential; we even think that without its use no balanced agricultural management could be established for those large areas, that cover most of the natural regions known as «Baixas do Sorraia» and «Baixo Alentejo Litoral».

As a matter of fact, no other legume has given the assurance of a good and regular yield throughout the years on those so adverse natural conditions. Even the serradella (*Ornithopus sativus* Brot.), that on favourable years can yield a large amount of fodder, fails, nevertheless, very often. Worse irregularity of yield has still been observed for some species of *Lathyrus* and *Vicia* and other *Leguminosae* tried, none of which has yet attained, in the above conditions, a reliable level.

The demonstration has not to be done here of the indispensability of a legume in a crop rotation whose aim is not to consume the low level of fertility but, on the contrary, to improve it. This need is universally accepted and comes chiefly from the capacity to absorb the atmospheric nitrogen, which makes optional the use of nitrogenous fertilizer.

In the pliocene region (Fig. 1-II) the yellow lupin was traditionally planted, but not very extensively, as a fall-winter crop to plow under for the grape-vine benefit. It was also used in some limited regions as sheep fodder.

(1) Entomologist and statistician, respectively.

EXPERIMENTS OF PEST CONTROL ON LUPIN
IN THE SANDY SOILS SOUTH OF THE RIVER TAGUS

DISTRIBUTION OF CENTRES IN 1948-1955

Fig. 1

The yellow lupin was considered a poor crop, not worthy of care, as far as planting and fertilizing were concerned. The sowing was made, very frequently, spreading only the seed, without any posterior operation, except sometimes a light harrowing; in both cases with no preliminar plowing. Preferably, it was the use to scatter the seed before the first rainfall, with the aim of an immediate germination and a early development, taking advantage of the relatively high temperatures of the early fall.

Very often, not even a planting was actually done, advantage being taken of the natural scattering of the seeds, so marked with this plant, too prone to natural threshing. Fertilizers very, very seldom were used.

In the miocene region (Fig. 1-I), the area including *L. luteus* was larger, since vast extensions were planted for sheep grazing and the grain used, after boiling, as pig feed.

Progressively, the total area has been enlarged from year to year and new uses started for the *L. luteus* as new applications were tried, since no cases of poisoning have been observed with the comsumption of this legume by sheep and cattle. This fact has not yet found due explanation, as it is known that the yellow lupin contains alcaloids which are considered very poisonous by many authors, leading its use to a complex toxic sindrom known as lupinosis, that often ends with the death of the animal affected.

The area turned to grazing is growing every year. This grazing takes different forms according to regional needs: the plant can be consumed green or after the hot weather has dried it; sometimes only the stubble, after the cutting of the flowering plant for silage or the harvesting for grain.

Out of the green matter is made good silage, without the need of any additive. This silage is very important in the economy of the farm, since it is stored to be consumed in the pasture lowest period of summer and early fall.

The straw is included as ballast in the sheep and cattle feed.

The seeds, naturally scattered before harvesting, even when they are slightly covered, are picked up by the grazing sheep. Part of the threshed grain is included as flour in the stock daily diet.

The use of the leaves and stems as green manure has been generalized to other crops rather than the grape-vine.

The seed value, facing a growing demand, has gradually climbed as to compare favourably with the bean prices.

The yellow lupin cannot be named from now on as a poor crop; but the farmer is still hard to persuade that it deserves better care. It is very slowly, that he, used to look at this crop as a « grow as you can » one, is changing to a more economically sound attitude, preparing improved seedbed and using more fertilizer.

Notwithstanding, there is a real progress: more and more farmers are using in their crop rotation larger areas of this legume. At the same time the lupin silage is being accepted, chiefly after the sucess of the trench silo method.

The two regions marked on the Fig. 1 are not the only ones where lupin is used, but they are by far the most important.

In the southern region, almost all originated from pliocene strata, the soils have homogeneous characteristics, showing profiles, the main distinction of which lies on the nature and depth of a compacted layer, more or less unpermeable (Cardoso, 1953-1955).

These characteristics led to consider tentatively 3 general categories:

1st type — Loose sand with no continuous unpermeable layer down to 1 meter
2d type — Unpermeable layer formed by the original material (compact sandstone)
3d type — Podzols.

In the northern region, almost entirely on miocene, the soils are included (Bramão *et al.*, 1948) in the category of regosols; other authors considered them as derived from sandstone. As in this region the pests have not the same importance they show in the southern one, a sub-division was not considered necessary.

Climatically, the pliocene region has a fairly uniform rainfall, as it is all crossed by the 600 mm isoieta. The northern part is under the 700 isoieta.

There are no marked differences, as far as temperature is concerned, between the two regions, both crossed by the 16° C isotherm.

The whole region is situated in the transition from the dry type to the humid type, as the isopleta 48 (Thornthwaite index, see Azevedo, 1953) is seen a few times over it.

In spite of the deeply marked natural conditions favouring the forest growing in the southern zone of the map, the need had arised to bring some of it to the production of cereals, since the usual wheat deficit is hardly compatible with the use of so large an area exclusively as forest.

The problem had to be faced by the agronomist as to bring about this transformation without reduzing the markedly low fertility, but just on the contrary, trying to build it up and get at the same time a larger yield of meat and other animal products. A dry-farming experimental center ([1]) was set up to deal with this particular study.

The striking capacity of the yellow lupin to thrive in so adverse conditions was known beforehand, so it was used from the start as green manure in order to improve the soil fertility through the incorporation of nitrogen and organic matter.

The notorious lack of organic matter of these soils could only be overcome by heavy manuring, which implies in turn a high density of livestock, only possible when there is the assurance of feed throughout the year. And also here the yellow lupin, either as silage or straw and grain, answered to this need of a larger reserve.

The importance of this lupin in the **crop rotation** under study in Pègões has increased step by step until, by 1943-1944, it took the following pattern:

A — *Yellow lupin* (grain)
B — *Yellow lupin* (grazed)
C — Serradela
D — Corn
E — Wheat
F — *Yellow lupin* (silage)
G — Wheat
H — *Yellow lupin* (grain)
I — Oats (grazed)

In this manner, the yellow lupin occupied four times, in a 9-year crop rotation, the same piece of land, two of them being consecutive (to take advantage of the natural seed scattering of the first year). This heavy use of the yellow lupin was chiefly

([1]) Posto "Experimental de Culturas de Sequeiro de Pègões" (40 miles SE from Lisbon), where most of these studies had taken place.

marked in one half of the rotation scheme where, of 4 years, 3 used lupin.

From the entomological standpoint there is, however, a rule according to which the use often repeated of a crop on the same land bring about the appearance, or at least the quick development, of pests until then unnoticed. This rule unfortunately, has also been observed in this case. During the years 1945-1946 until 1947-1948 the yellow lupin crops were increasingly attacked, in such a way that in some cases no crop or almost none was harvested.

Facing such damage, that challenged all the structure of the crop rotation on trial, the cooperation of an entomologist was asked for to study these pests and advise the adequate control measures. Since then and until 1955, a series of studies had been performed, which are reported here in a summary feature, including the data statistically analysed (Silva & Oliveira, 1948-1955).

MANAGEMENT OF EXPERIMENTS

Pests and insecticides

The annual reports of the men in charge of the experiments in Pègões began to point out, since 1945-1946, that the yellow lupin crop was more and more the aim of the insect pests (R. S. C. Arvenses, 1946-1948).

The study of the problem thus arisen began during 1948 by evaluating the nature and the evolutions of the damage, individualizing their agents and recognizing cause-effect relationship, and emphasizing the pests with the larger and more widespread destructiveness.

Very soon it was observed that two different kinds of damage were present, each one brought about by a different species of insect: in the first type, the seedlings were found wilted on the ground with the stem gnawed from the inside by a maggot; in the second one, less frequent, the terminal bud was completely destroyed, leaving the plant hopelessly handicapped. This second type was recognized to be the responsability of a curculio, found very frequently on the plants.

A third type of damage, noticed only on a few plants, was the result of the activity of some species of cut-worms *(Noctuae)* that completely devour the aerial part of the plants.

Later on another type of damage was found, but this time on the subterranean part, where the root nodules were totally or partially destroyed by the larvae of some *Curculionidae*, exactly the ones whose imagos eat the terminal bud. This type of damage was afterwards recognized as the most important, being normally constant and affecting almost all the plants.

Chemical analyses proved this damage to be of two different kinds; the destruction of the root nodules involving not only the reduction of the total weight of the plant but also the lowering of the protein contents of the green matter. This find enlarges very much the importance of the damage done. Difficulties concerning the sample collection and preparation have not yet allowed the accurate determination of that reduction. The values found point to a means somewhat around 0.5 % of dry matter.

As a common feature to all the damages referred, it was observed that they are of much more concern when seedlings or young plants are attacked, their importance being reduced as the plants grow up.

As a matter of fact, the larvae of the seedlings fly (*Hylemya cana* Meig) are no more able to get into the little stems as soon as these develop a certain hardness; from then on the plant is free from the attack of this pest.

Similarly, if the attack of the *Curculionidae* (*Sitona gressorius* F. and *S. griseus* F.) comes only when the nodules are being formed, these are destroyed one by one. This is no more possible when most of them are developed to a large size. Then they can stand the attack without a marked reduction in yield.

As far as the cut-worms are concerned, they cannot eat completely the plants when these show a few leaves, even in the case of a heavy outbreak. Then the plants can recover afterwards and the damage is not total as it use to be when the attack is aimed at the seedlings or young plants.

In a separate paper a description of the biology of these pests will be given (Silva, in press).

These remarks make clear the point that it exists for the yellow lupin, regarding its pests, a critical period, beginning with the germination of the seed and lasting until some root nodules are completely formed.

Obviously then, all the conditions that favour the shortening

of this period or, in other words, that enhance a good start to the seedlings, will be decisive for a good crop, since they offer to the pests no opportunity to cause heavy damage.

Another point is worth to emphasize in this moment: the briefness and simultaneity of the germinating period. Nothing is worse than a prolonged germination of the seeds; the growing insects progressively find seedlings in the optimal conditions to be attacked during a large period of time.

On the contrary, a quick and simultaneous germination of the seeds, even facing a heavy outbreak of the pest(s), always allow to survive this critical period a sufficient large number of plants to warrant a good yield, in spite of the destruction of some of them. *Prompt and simultaneous germination is then the condition to provide to the yellow lupin crop in order to assure regularly good yields.*

The characteristic showed by all those economically important pests, of spending in the soil an important fraction of their life cycle, led us from the starting to try to control them with the use of those insecticides that had better proved against other soil pests.

At the time, it was the BHC the insecticide of more generalized use as such, after the striking action showed against the wireworms.

From the beginning a very good control was noticed, expressed in the fact of limiting to less than 10 % an over all attack recorded in the check plots. The value of BHC as a plant protector raised considerably when it was recognized that its action lasted, almost unchanged, for more than three years.

Unfortunately, its use had to be discontinued, due to the off-flavour taken by the crops grown in the same soil, chiefly potatoes, during at least four years after the application. To this draw-back another one is added: it shows pratically no action against the *Noctuae*, mainly the full grown larvae.

Some other chlorinated insecticides were added to the experiments, after DDT and Parathion had shown little promise.

First of all, Chlordan, that gave less control of the *Sitonae* than BHC, but a fair control of the *Noctuae;* a residual effect not covering two years of economic control, however, reduced largely its value. Later, Dieldrin was considered, which proved to fulfill all the necessary requirements: a better control of the *Sitonae* than

Chlordan (pratically in the same level as the BHC) and equal good control of the *Noctuae*, with a residual effect of two years. This allows the skipping of a treatment during a complete crop rotation.

In all these experiments, the insecticide application was logically made with the planting.

The *Hylemya*, in spite of no quantitative records of their control — due to the difficulty of getting reliable counts of the dead plants — showed reduced incidence with the use of any of those insecticides. The available literature on this subject points out good results with them, chiefly with BHC and Dieldrin (Lilly, 1956).

Taken in account the characteristics, in some way complementary, of the BHC and Chlordan as far as the control of all the pests is concerned, mixtures of the two have been tried, to detect any possible synergistic action — allowing a reduction of the amount of the insecticides used and consequently the cost of the treatment. As no trend in this direction was recognized, this line of work was discontinued.

According to the same idea, the seed treatment was investigated for all of these insecticides, using a mixture of sand and insecticide. The results showed no practical protection.

At the same time, the phytotoxic action of the three insecticides was studied. All of them interfere with germination, that is practically inhibited by BHC when applied wet. With a dry application, notwithstanding, and below a certain dose, much heavier than the usually needed, all of them proved to be inocuous.

The experiments of artificial control using insecticides were all set-up with statistical basis. In Table I is shown the number of experimental fields for experiments of pest control carried out at several places in years 1948-1955. Since the *Hylemya* proved to be of relatively minor importance and as the *Noctuae* outbreaks showed only every few years, an effectiveness index was used concerning only the *Sitonae*.

Sampling

To get an idea of the progress of the infestation by this last species, three samplings were performed during the growing period of the yellow lupin crop: the first before the end of

December, the second in February and the last just before harvest (March-April).

As a sampling unit, the plants within a rectangular frame (1 m × 0.50 m) placed at random in each experimental plot were picked and classified according to the root damage showed, due

TABLE I

Number of experimental fields for trials of pest control by means of insecticides and crop management pratices conducted at several places in the years 1948-1955.

Locality	Year							Totals
	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	
Gorjão	—	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	—	5 (5)
Salvaterra de Magos	—	—	—	1 (1)	1 (1)	—	—	2 (2)
Pègões (P. Exp.)	1 (1)	4 (2)	3 (1)	7 (1)	5 (1)	—	—	20 (6)
Pègões Velhos	—	2 (1)	3 (1)	3 (1)	5 (2)	6 (3)	(—)	19 (8)
Zambujal	—	—	1 (1)	1 (1)	3 (1)	—	—	5 (3)
Canha	—	—	1 (1)	1 (1)	1 (1)	—	—	3 (3)
Arcebispa	—	—	—	1 (1)	1 (1)	—	—	2 (2)
Grândola	—	—	—	1 (1)	1 (1)	6 (3)	—	8 (5)
Totals	1 (1)	7 (4)	9 (5)	16 (8)	18 (9)	13 (7)	(—)	64 (34)

NOTE: In brackets are shown the numbers of experimental fields for insecticide trials (excluding a 1954-55 experiment which begun two years before).

Number of experimental fields: for planting time, 8; seed-bed preparation, 9; fertilization, 8, and soil acidity correction, 5.

to the *Sitona* larvae activity. From the number of plants attacked, the percentage of infestation was obtained (« index I »).

Later on, it was found advantageous to consider two categories of attack: « heavy » and « light », corresponding the first one to the economic damage. This new index, henceforth named as « index II », proved to be in a much closer correlation to the yield of green fodder. Consequently it was adopted. It is really logic this finding, coming from the formerly described pattern and timing of the attack, since it is known that one or more larvae, included in a full-grown nodule, which they devour only partially, cannot affect considerably the yield. The yield is only reduced noticeably when the nodules are completely destroyed, with the consequent loss of the capacity of nitrogen fixation.

In the general set up of experiment in the field some conditions were sought.

Seedbed preparation

The seedbed, when not specifically required by some experiments, was prepared in the usual way of the region: ploughing with oxen, followed by harrowed again crosswise after the sowing.

In all the experiments at Pègões and neighbourhood we used instead a tractor disking, followed by another disking after the sowing.

These two types of tillage are referred from now on as «harrowed», always as opposed to a deep tractor ploughing («ploughed»).

Plot area

The plot area used to be 225 m^2 in the first year. For practical reasons it was reduced, from the second year on, when the number of the experiments and plots was considerably enlarged (It would not be possible then to weigh carefully the huge amounts of green matter yielded by each large plot).

The mean size of the plots mostly used, from the second year on, was 80 m^2 or 60 m^2, which proved to be quite satisfactory. Only in the last year of this work, the difficulty of finding areas with the high homogeneity required by the experiments dealing with their differention has forced a further reduction to 35 m^2.

Among the plots, marked at each corner with a stake, a corridor was left, 0.60 to 1.00 m wide, at least in one direction. Sometimes *Lupinus angustifolius* was planted there in order to delineate more strikingly the border.

Planting

Concerning the planting, as with all the other operations not specifically mentioned, the routine of the Pègões Experimental Center was followed. Accordingly, in all experiments, except of course those where the amount of seed was the variable, 100 l/ha were used. This amount, that looks too heavy, has been reached as the years passed, with the idea of countereffecting the attack of the *Hylemya,* that destroys a lot of seedlings.

Insecticide application

The insecticides, when used as sprays, were applied with a watering can; the powders were always preferred when available, because of their easier and quicker application. As the amounts to be applied were so small for a relatively large area, they were incorporated in sand, to make possible an even distribution (in the same way as a fertilizer).

Harvest

The cutting of the green fodder was carried out as a rule at the generalized blossom stage — end of March, first week of April in that region.

A row was cut and discarded along the margins of the plots, hence reducing the border effect. This was done a little before the cutting of the plots, and the fallen plants pulled away from the borders, under the purpose of defining the plots more clearly, emphasizing the differences.

Much stress was put upon a quick cutting with immediate weighing, in order to minimize the lost of weight that could introduce large errors. With the same aim, the blocks of replicates were cut in proper order, the operations never stopping before each one was completed.

The weighing of the green fodder, harvested with a scythe and immediately gathered, was progressively simplified as the experience suggested alterations to the procedure. In the last two years it was carried out much quicker, thanks to the adoption of a spring weighing scale, suspended from a stick held by two men. The harvested plants were gathered in a large cloth provided with two wires, easily trapped in a scale hook.

To make possible a comparison among the yields of all the years, harvested in different conditions of moisture, all the data were transformed in dry weight. Samples cut from the plots in supposed different conditions were immediately weighed and brought to the laboratory; here they were dried until constant weight: thus the converting factors were calculated.

It was recognized to be ill advised the use of local unskilled personnel to mark and plant the experimental plots and harvest them, since it took much longer and implied a very high risk of error. When possible, the skilled personnel of the Pègões Experi-

mental Center was transported with all the needed material to the formerly elected sites.

In spite of the remarkable rate of work thus achieved, it would not be possible without special help to master the high number of experimental fields that statistics showed as convenient for an attempt to characterize the region and sub-regions. This is only feasible with the use of various crews, working the same way.

As this was not possible for the time being, only the more modest schemes that the possibilities allowed were used. The results for the 1948-1949 period were considered as preliminary and hence are not shown in this paper.

RESULTS AND DISCUSSION

Insecticides

As mentioned, three successive samplings were performed on every experiment for all the five years of the period 1949-1954 (Only the data for the third sampling are given here — Tables III-V).

Summarising all the available information concerning the trend of infestation on the check plots, it is known now that the attack is not pratically total from the second sampling on, as it was observed during the three first years of experiments.

This reappraisal of the observations from the third year on gives weight to the risk of generalizing the results obtained in only one year of experiments, or even two or three. If the experiments had been discontinued at the end of the third year, we would had been led to accept the total attack as the only pattern. Instead, three patterns of infestation by the *Sitona* larvae can now be considered:

a) Early total infestation, December-January (most common)
b) Late total infestation (reaching 100 % only in March)
c) Lighter infestation (less then 80 % at harvest time).

Evidently the yield is affected in different ways by these types of infestation and the effect of the insecticide application will be very different in each case. This comes out of the observation, once more pointed out, of a critical period of plant susceptibility to the pests, lasting until a few nodules are formed.

Generally speaking, the yield would be much more affected during the years of early infestation, suffering much less in the other two cases. One cannot, however, state as definite this principle, since an early infestation can only be observed in those years with somewhat abundant rainfall in September, rainfall that represents, on the other hand, the best hope for high yield. Contrarywise, a late infestation is normally connected with a late growth of the plants, that necessarily leads to lower yields.

The two factors are then considered in this analysis at the same time: early infestation by the *Sitona* larvae and the early rainfall, followed or not by rains in favourable periods and amounts.

Logically, one may hope for a maximum yield in those years which show favourable meteorological factors both to the crop and to the pests, if the last ones are controlled by the application of an insecticide. The differences for the checks will be less important proportionally, but not so when their absolute values are considered.

If the meteorological conditions, by a small lag, are favourable to the crop without favouring the pest, high yields are also to be expected.

The large differences between the checks and the controlling treatments are found in the years of observed high infestation and weather conditions adverse to the crop.

The soil types are evidently expected to introduce a factor of confusing to the above reasoning, since they can even mask some of the expected effects. In spite of that, we think to be justified, even with a tentative classification of the soils, to accept the superiority of the No. I type to the production of the yellow lupins in normal conditions of weather and without any special treatment ([1]).

Actually, only one experimental field of type II (Canha, 1951-52, in a somewhat heterogeneous soil with some appearance of the type I), shows a high yield on the checks, in one year of heavy infestation but favourable weather conditions.

As far as the insecticides are concerned, their action upon the *Sitona* larvae is also affected by the way the infestation goes on. It is under an early heavy attack, when the plants are more

([1]) The soils of the II and III types, when adequately fertilized, are able to yield considerably, giving higher reactions to the fertilizers than the type I soils.

susceptible, that, evidently, the protection from the treatments will show up. It is also during this period that the nodules, due to their small size, do not allow the penetration of the larvae, failing thus to give them protection against the action of the insecticide incorporated in the soil.

One nodule is not enough to provide the feed needed for the complete development of a larva. This has to seek new ones, moving through the soil and thus widening the chances to get in contact with enough insecticide to be affected. On the contrary, with more developed nodules, sufficiently large to harbour a small larva, this one can be able to reach shelter without contacting any insecticide and so will be henceforth out of reach of its poisonous action.

In order to get a general view of the studies of pest control, carried out during the five years period 1949-1954, the data concerning the insecticide trials were put together.

In these experiments a few insecticides were tried, the types and doses of which are shown in Table II.

TABLE II

Insecticides treatments included in pest control experiments on yellow lupin at several places during the years 1949-1954

Insecticide	Symbol	Dose	
Dieldrin	*P*	6	kg/ha of 25 % wettable powder
	N	4	
	M	2	
Chlordan	*L*	2.5	l/ha of 75 % emulsion
	D	1.5	
	I	0.75	
BHC	*E*	75	kg/ha w. p. (1)
	H	25	
Check	*T*	no insecticide dose	

(1) 'Agrocide', dosing 0.45 % of γ BHC.

As referred, all the experiments were properly designed year by year and their results statistically treated (Tables III-V). In these Tables are shown, for each experiment, the average number of plants per square meter, the infestation by the *Sitona* larvae (indices I and II) and the yield (green matter) — taking in account the three soil categories considered as working hypothesis. This set up gives the possibility of detecting any probable effect of the soil conditions on the efficiency of the pest control.

For both the infestation and the yield data, included in Tables III-V, the respective standard errors are given. (The infestation data were first transformed to angles as usual).

For the time being we are restricted here to emphasize only the general conclusions found on direct reading of the Tables III-V, presented now with stronger evidence.

Considering the isolated effect of the insecticides on the infestation, it can be seen that BHC, with dose *E*, has reduced markedly, in all cases, the number of plants affected.

Chlordan showed an acceptable protection, mainly with the highest dose *L*, but inferior to BHC.

Dieldrin offered, with the heaviest dose *P* used in the experiments, the broadest spectrum of insecticidal effects, giving a protection against the *Sitona* of the order of BHC, and controlling at the same time the *Noctuae*.

The *N* dose showed similar good standing, but naturally on a somewhat inferior level. Notwithstanding, it should be the one economically accepted, given the high cost of the insecticide; there are even reasons to think that the optimal economic dose should be situated between *N* and *M* (2 kg/ha, 25 % w. p.).

All this revision (it has to be stressed) has been done according to the infestation by the *Sitona* larvae, the only one that the indices take in account. In spite of that, the small occurence of *Noctuae* outbreaks and the minor importance of the *Hylemyae*, enables us to consider it practically sound.

All the treatments with insecticides involved gains of yield of more or less importance; only the lowest doses of Chlordan and BHC lacked to show some effect.

Attention is called to the positive correlation between the number of plants and the yield. This proves the yield gain to be due not only to a better growth of the plants but also to a higher number of plants saved by the action of the insecticide.

TABLE III

Average values of number of yellow lupin plants per square meter; percentage of infestation by the Sitona *larvae showed on the third sampling (indices I and II) and yield (q/ha). Soils of type I.*

Insecticide	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare
	Gorjão (Chamusca) 1949-50				Abegoaria (Canha) 1950-51				Gorjão (Chamusca) 1950-51			
Dieldrin *P*	—	—	—	—	—	—	—	—	—	—	—	—
N	—	—	—	—	—	—	—	—	—	—	—	—
M	—	—	—	—	41	48	—	28.7	42	3	—	23.2
Chlordan *L*	—	—	—	—	32	48	—	26.7	47	3	—	25.9
D	43	25	—	38.8	26	75	—	25.6	42	0	—	25.7
I	40	64	—	39.1	28	66	—	23.7	45	0	—	29.8
BHC *E*	40	21	—	37.7	21	46	—	21.8	42	2	—	26.0
H	33	60	—	37.3	12	82	—	14.3	51	12	—	22.9
Check *T*	37	96	—	35.6	14	97	—	17.1	50	20	—	27.1
Exp. error		± 3.5		± 1.6		± 5.5		± 4.4		± 4.2		± 2.6
Insecticide	Gorjão (Chamusca) 1951-52				Salvaterra de Magos 1951-52				Pègões Velhos 1951-52			
Dieldrin *P*	24	16	—	23.3	40	18	—	36.6	57	0	0	20.4
N	28	23	—	21.5	33	26	—	35.9	48	4	1	22.2
M	28	33	—	25.4	59	48	—	37.5	44	7	3	19.6
Chlordan *L*	28	44	—	23.7	40	33	—	35.1	50	4	1	15.9
D	34	50	—	20.4	47	28	—	36.1	49	9	3	17.0
I	30	75	—	25.2	46	61	—	35.1	48	27	7	18.9
BHC *E*	37	19	—	24.3	50	26	—	37.9	65	8	2	20.8
H	33	48	—	25.4	37	68	—	34.0	38	37	12	17.1
Check *T*	30	94	—	19.7	45	91	—	35.1	55	55	18	16.4
Exp. error		± 4.1		± 2.9		± 4.1		± 1.6		± 3.9		± 1.7
Insecticide	Pègões Exptl. Center («F») 1951-52				Zambujal (A. Moura) 1951-52				Arcebispa (Alc. do Sal) 1951-52			
Dieldrin *P*	26	2	0	36.4	51	5	0	41.7	58	7	—	—
N	18	3	0	34.2	57	8	1	40.7	35	7	—	—
M	21	18	0	37.2	44	27	1	40.4	50	24	—	—
Chlordan *L*	27	4	1	33.0	42	11	0	43.6	34	8	—	—
D	26	10	1	32.4	42	28	0	44.4	50	12	—	—
I	25	25	4	36.6	45	47	4	44.4	35	37	—	—
BHC *E*	30	3	0	36.4	50	29	1	41.9	40	31	—	—
H	25	28	4	34.5	49	42	4	39.9	43	26	—	—
Check *T*	22	57	20	34.3	37	97	21	36.2	56	91	—	—
Exp. error		± 3.9		± 2.6		± 3.9		± 2.4		± 5.0		

TABLE III *(Cont.)*

Insecticide	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare
	Monte Novo (Grândola) 1951-52				Zambujal (A. Moura) 1952-53				Arcebispa (Alc. do Sal) 1952-53			
Dieldrin *P*	46	6	—	36.2	42	26	8	44.1	41	22	5	32.4
N	42	27	—	35.6	54	36	12	46.0	30	69	0	32.5
M	41	47	—	32.2	34	52	19	36.0	23	72	22	28.6
Chlordan *L*	48	15	—	35.8	32	85	28	45.6	35	64	12	33.2
D	43	32	—	38.1	38	96	60	36.1	23	92	31	30.0
I	46	40	—	34.3	—	—	—	—	—	—	—	—
BHC *E*	36	15	—	38.1	42	57	11	48.9	32	48	17	29.3
H	43	47	—	32.9	—	—	—	—	20	76	40	36.0
Check *T*	42	93	—	34.6	34	55	11	42.2	22	60	10	35.6
Exp. error		± 5.5		± 1.0		± 8.4		± 3.5		± 8.7		± 1.1
Insecticide	Pègões Exptl. Center («F») 1952-53				Salvaterra de Magos 1952-53				Gorjão (Chamusca) 1952-53			
Dieldrin *P*	41	7	0	40.0	52	15	3	45.3	36	38	8	20.1
N	47	14	0	44.6	36	31	13	36.6	40	10	2	15.8
M	38	28	0	37.6	45	43	18	43.3	64	22	6	18.2
Chlordan *L*	24	38	2	32.3	43	69	38	36.6	57	54	15	16.7
D	32	79	14	39.6	28	55	25	38.1	50	55	22	20.5
I	—	—	—	—	—	—	—	—	—	—	—	—
BHC *E*	31	40	3	38.0	37	33	13	40.8	56	8	2	15.7
H	—	—	—	—	—	—		—	52	50	22	14.7
Check *T*	13	74	9	29.6	42	91	41	36.2	46	79	38	13.2
Exp. error		± 8.2		± 2.9		± 8.3		± 3.7		± 10.3		± 2.1
Insecticide	Gorjão (Chamusca) 1953-54				Pègões Velhos 1953-54				Monte Novo (Grândola) 1953-54			
Dieldrin *P*					—	—	—	—	—	—	—	
N	45	42	9	25.7	31	69	2	4.8	59	58	12	10.3
M	—	—	—	—	—	—	—	—		—	—	—
Chlordan *L*	—	—	—	—	—	—	—		—	—	—	—
D	—		—		—			—			—	
I	—				—		—		—	—		
BHC *E*	27	68	0	26.6	37	15	0	9.6	47	17	5	11.5
H				—					—	—	—	—
Check *T*	40	85	35	18.5	20	76	35	9.2	38	78	12	12.0
Exp. error		± 8.0		± 3.5		± 7.3		± 3.0		± 8.3		± 4.1

NOTE: Generally averages of 3 replicates. The standard error for infestation data concerns the angular trensformation of index I.

All the trials at Pègões Velhos were carried out in the «Junta de Colonização Interna» estates.

TABLE IV

Average values of the number of yellow lupin plants per square meter; percentage of infestation by the Sitona *larvae showed on the third sampling; and yield (q/ha). Soils of type II.*

Insecticide		Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare
		Pègões Velhos 1949-50				Pègões Velhos 1950-51				Zambujal (A. Moura) 1950-51			
Dieldrin	*P*	—	—	—	—	—	—	—	—	—	—	—	—
	N	—	—	—	—	—	—	—	—	—	—	—	—
	M	—	—	—	—	29	66	—	15.7	12	66	—	8.6
Chlordan	*L*	—	—	—	—	31	31	—	18.9	11	48	—	8.4
	D	31	88	—	12.0	30	55	—	16.7	6	81	—	5.7
	I	36	96	—	9.2	31	76	—	14.5	—	—	—	4.0
BHC	*E*	34	80	—	14.2	30	50	—	10.5	5	48	—	4.6
	H	30	96	—	8.4	17	70	—	8.3	—	—	—	4.8
Check	*T*	25	99	—	8.3	18	97	—	9.7	4	99	—	2.9
Exp. error			± 1.9		± 4.7		± 8.4		± 3.6		± 5.5		± 8.9
Insecticide		Abegoaria (Canha) 1951-52				Balsa (Canha) 1952-53				P. Velhos (Octob. planting) 1952-53			
Dieldrin	*P*	51	1	1	38.6	35	12	2	10.9	52	19	0	7.8
	N	52	4	0	32.7	43	35	13	13.4	18	45	25	5.9
	M	52	14	1	32.2	42	57	28	11.2	37	22	19	4.0
Chlordan	*L*	52	11	4	31.0	31	59	7	10.2	27	41	7	8.0
	D	45	15	3	30.6	42	70	18	8.2	23	48	25	3.5
	I	54	24	8	32.3	—	—	—	—	—	—	—	—
BHC	*E*	47	13	1	34.8	50	22	8	9.9	27	19	3	3.7
	H	50	35	4	31.8	29	31	31	5.2	—	—	—	—
Check	*T*	55	92	16	38.4	36	99	78	4.2	25	88	35	3.9
Exp. error			± 5.3		± 2.6		± 8.8		± 2.8		± 14.9		± 3.0
Insecticide		Monte Novo (Grândola) 1952-53				Pègões Velhos 1953-54				Monte Novo (Grândola) 1953-54			
Dieldrin	*P*	—	19	0	—	—	—	—	—	—	—	—	—
	N	—	30	8	—	31	44	7	2.2	51	64	7	32.6
	M	—	33	2	—	—	—	—	—	—	—	—	—
Chlordan	*L*	—	17	0	—	—	—	—	—	—	—	—	—
	D	—	41	19	—	—	—	—	—	—	—	—	—
	I	—	—	—	—	—	—	—	—	—	—	—	—
BHC	*E*	—	13	0	—	38	12	0	4.7	48	22	0	34.4
	H	—	38	5	—	—	—	—	—	—	—	—	—
Check	*T*	—	91	31	—	42	33	10	4.1	46	84	2	30.3
Exp. error			± 3.0		—		± 8.0		± 2.1		± 4.7		± 1.9

NOTE: Generally averages of 3 replicates. The standard error for infestation data concerns the angular transformation of index I.

The 1949-50 Pègões Velhos is a second year crop.

TABLE V

Average values of number of plants/sq. m; percentage of infestation by the Sitona *larvae showed on the third sampling; and yield (q/ha). Soils of type III.*

Insecticide		Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare	Number of plants	Infest. Index (%) I	Infest. Index (%) II	Yield q per hectare
		Pègões Exptl. Center («C») 1949-50				Pègões Exptl. Center («I») 1949-50				Pègões Exptl. Center («H») 1950-51			
Dieldrin	*P*	—	—	—	—	—	—	—	—	—	—	—	—
	N	—	—	—	—	—	—	—	—	—	—	—	—
	M	—	—	—	—	—	—	—	—	27	31	—	26.6
Chlordan	*L*	—	—	—	—	—	—	—	—	33	22	—	33.0
	D	33	81	—	38.1	30	48	—	49.3	30	24	—	25.6
	I	30	88	—	29.7	29	77	—	37.6	—	—	—	11.7
BHC	*E*	40	70	—	35.0	30	41	—	40.5	12	31	—	16.5
	H	29	95	—	27.9	30	85	—	40.9	—	—	—	11.6
Check	*T*	36	96	—	21.1	26	99	—	26.1	(2)	99	—	2.2
Exp. error			±3.0		±4.3		±3.4		±2.1		±2.6		±4.6
Insecticide		P. Velhos (Sept. planting) 1952-53				Pègões Velhos 1953-54				Monte Novo (Grândola) 1953-54			
Dieldrin	*P*	18	62	34	3.3	—	—	—	—	—	—	—	—
	N	16	88	48	4.3	30	78	10	23.3	46	84	45	13.6
	M	18	14	0	2.7	—	—	—	—	—	—	—	—
Chlordan	*L*	15	93	17	1.1	—	—	—	—	—	—	—	—
	D	33	28	12	1.4	—	—	—	—	—	—	—	—
	I	—	—	—	—	—	—	—	—	—	—	—	—
BHC	*E*	14	22	4	1.5	24	22	1	14.5	40	19	5	10.5
	H	—	—	—	—	—	—	—	—	—	—	—	—
Check	*T*	23	70	35	1.4	23	70	5	19.1	29	96	50	7.3
Exp. error			±14.9		±3.0		±8.7		±4.4		±6.1		±3.1

NOTE: Generally averages of 3 replicates. The standard error for infestation data concerns the angular transformation of index I.

With the purpose of stressing the contrast among the insecticide treatments, the results of the respective trials (not ploughed nor fertilized) per location have been put together in Table VI that includes the mean yields, in kg/ha of dry matter, for each year and type of soil. In this Table are shown only the experiments (sometimes with incomplete data) where heavy infestations have

TABLE VI

Mean yield (dry matter), in metric quintals, for three types of soils, obtained from insecticide experiments carried out at several places in 1949-54.

A. Soils of type I

Insecticide		1949-50	1950-51	1951-52				1952-53					1953-54	
		Gorjão	Canha	Gorjão	S. Magos	Zambujal	Grândola	Gorjão	S. Magos	Pègões Exptl. Center («I»)	Zambujal	Arcebispa	Gorjão	Grândola
Dieldrin	*P*	—	—	34	62	38	43	21	51	42	39	39	—	—
	N	—	—	31	61	37	42	16	43	47	40	40	26	12
	M	—	32	36	64	37	39	19	50	40	32	34	—	—
Chlordan	*L*	—	30	34	65	40	43	17	44	35	40	40	—	—
	D	42	27	30	61	41	45	21	45	42	32	36	—	—
	I	42	26	36	59	41	41	—	—	—	—	—	—	—
BHC	*E*	41	25	35	64	38	45	16	47	41	43	36	26	14
	H	40	16	36	56	37	39	15	—	—	—	46	—	—
Check	*T*	39	19	29	59	33	41	14	41	32	37	43	18	—

		B. Soils of type II							C. Soils of type III					
Insecticide		1949-50	1950-51		1951-52	1952-53		1953-54	1949-50		1950-51	1952-53	1953-54	
		P. Velhos	P. Velhos	Zambujal	Canha	Canha	P. Velhos	Grândola	Pègões Exptl. Center («C»)	Pègões Exptl. Center («I»)	Pègões Exptl. Center («H»)	P. Velhos	P. Velhos	Grândola
Dieldrin	*P*	—	—	—	43	12	10	—	—	—	—	3	—	—
	N	—	—	—	37	15	8	41	—	—	—	3	34	18
	M	—	16	9	36	12	5	—	—	—	26	2	—	—
Chlordan	*L*	—	20	9	35	12	10	—	—	—	36	2	—	—
	D	14	17	6	34	9	4	—	42	48	27	4	—	—
	I	9	15	4	33	—	—	—	32	36	13	—	—	—
BHC	*E*	16	11	6	39	11	5	42	34	41	19	1	21	14
	H	9	9	5	35	6	—	—	36	40	13	—	—	—
Check	*T*	8	11	3	36	5	5	37	23	24	3	1	27	9

NOTE: Generally averages of 3 replications. The plots on these experiments were not ploughed nor fertilized.

been noticed, in order to get more homogeneity for the data and allow an empirical classification of the different treatments; but even so the conclusions stand for all the experiments.

To the analysis of tables of triple classification presenting a few empty cells some conventional least squares method has to be used. As this is usually very laborious, a more feasible method developed recently by HENDERSON (1953) is tried, which has already been referred in this country (OLIVEIRA, 1958).

Let us suppose appropriate to non-orthogonal three-way tables of observations, like Table V part A — in which the main classifications are places, varieties and years — the mathematical model

$$y_{hijk} = m + p_h + v_i + a_j + (va)_{ij} + e_{hijk} \tag{1}$$

where,

$$\begin{aligned} h &= \text{place number} &&= 1, 2, \ldots, p \\ i &= \text{variety number} &&= 1, 2, \ldots, q \\ j &= \text{year number} &&= 1, 2, \ldots, r \\ k &= \text{plot number} &&= 1, 2, \ldots, n_{hij} \end{aligned}$$

and where all the elements but m are uncorrelated random variables with means of zero and variances σ_p^2, σ_v^2, σ_a^2, σ_{va}^2, and σ_e^2.

According to the type of material we are combining, places can be taken as the fixed factor, because the locations where the insecticide trials were conducted are not truly a random sample of locations for the region. In this way, the least squares estimates of the p's for the yellow lupin yield data of Table V, part A (now expressed in kg/ha), are the following:

$$\begin{aligned} \hat{p}_1 &= -1062.207 & \hat{p}_4 &= -\ 402.154 \\ \hat{p}_2 &= 1424.675 & \hat{p}_5 &= -2106.434 \\ \hat{p}_3 &= 60.381 & \hat{p}_6 &= 182.674 \end{aligned}$$

with $\hat{p}_7 = 0$, in correspondence respectively with the places: Gorjão, Salvaterra de Magos, Pègões Experimental Center, Zambujal, Arcebispa, Grândola and Canha.

With those estimates the data can be adjusted. The corrected subclass and class totals (in kg/ha) are shown in Table VII.

TABLE VII

Adjusted yield subclass and class totals (dry matter in kg/ha) for trials conducted at several places. Soils of type I.

Insecticide		Years					Total	Mean
		1949-50	1950-51	1951-52	1952-53	1953-54		
Dieldrin	*P*	—	—	5,360	3,400	—	8,760	4,380 (20)
	N	—	—	5,190	3,260	940	9,390	3,910 (24)
	M	—	960	5,310	3,080	—	9,350	4,060 (23)
Chlordan	*L*	—	900	5,490	3,040	—	9,430	4,100 (23)
	D	1,240	820	5,360	3,050	—	10,470	3,880 (27)
	I	1,260	780	5,360	—	—	7,400	3,890 (19)
BHC	*E*	1,200	760	5,520	3,240	970	11,690	3,770 (31)
	H	1,170	480	5,100	930	—	7,680	3,660 (21)
Check	*T*	1,130	580	4,910	2,870	830	10,320	3,330 (31)
Total		6,000	5,280	47,600	22,870	2,740	84,490	

NOTE: In brackets are given the total number of plots for each case.

Under the given model, the estimates of the components of variance obtained, after a very time consuming computation, are as follows:

	Places as random factor	*Places as fixed factor*
s_v^2	57,552.032	74,788.955
s_a^2	529,223.503	777,549.333
s_{va}^2	— 118,359.441	— 123,486.095
s_e^2	846,587.080	788,582.210

and yet $s_p^2 = 855{,}679.032$ for the first case.

Concerning the standard errors for the adjusted treatment means over a fixed number of places for all years, we must take in consideration the values of the C^{ij} matrix, which can be seen at Table VIII.

For the comparison between *T* and *I* treatments, for instance, the value 560 ± 382 kg/ha (in dry weight) is obtained, which means that the difference between them does not reach the level of significance. In the case *T versus L*, the difference between the respective adjusted means is now significant (770 ± 362 kg/ha).

Any other comparisons for insecticides can be similarly made; as the computations are tedious, only the dubious cases are worth trying.

The above laborious method has not been applied to the incomplete data of soil types II and III. Notwithstanding, in order to have some idea about the effect of the insecticides for these soils, the weighed means, with weights in proportion to the number of replications, were computed (to counterbalance some paucity of data, results for the two soil types were taken together).

TABLE VIII

Coefficients of the matrix C^{ij} (1)

0.057,909,0	0.027,062,7	0.005,953,6	0.027,062,7	— 0.130,437,9	0.039.998,3
	0.048,305,2	0.006,587,1	0.023,915,0	— 0.131,980,2	0.032,316,0
		0.078,449,1	0.006,587,1	— 0.133,035,6	0.006,321,4
			0.048,305,2	— 0.131,980,2	0.032,316,0
				— 0.139,854,8	— 0.131,333,5
					0.078,548,3

(1) Only the upper right corner of the matrix is reproduced.

Some general conclusions can be reached about the effect of the insecticides on the pests of the yellow lupin crop, with respect to yield and infestation. Accepting for the checks an infestation of the 80-100 % level, a ranking has been lined up as to the effect of the insecticides on the infestation:

60 % to 80 % — Negligible
40 % to 60 % — Regular
20 % to 40 % — Good
0 % to 20 % — Very good

All the pertinent data for the three types of soils are included in Table IX. The classification of infestation for every year is not shown; in columns 4 and 7, however, is specified a general qualitative appraisal (sometimes backed up with the qualitative appreciation from yield) obtained chiefly from the three intermediate years.

According to the gains in yield due to the use of insecticides, the former conclusions, that came out of the comparison of infest-

ation levels, are maintained. The results show a close correlation, proving the gains to be due to the control of the insect pests by the selected products.

During the year of application, Dieldrin showed the best control of all the pests as compared with the other insecticides.

TABLE IX

Mean yields (and respective indices), and qualitative appraisals for the insecticides in experiments conducted over several places during 1949-1954.

		Soils of type I			Soils of types II and III		
		Adjusted mean		Insecticide ranking	Weighed mean		Insecticide ranking
		kg/ha	Index		kg/ha	Index	
Dieldrin	*P*	4,380	132	very good	2,800	185	very good
	N	3,910	117	good	3,000	187	good
	M	4,060	122	regular	1,800	112	regular
Chlordan	*L*	4,100	123	good	1,900	119	good
	D	3,880	117	regular	1,600	100	regular
	I	3,890	117	negligible	1,500	94	negligible
BHC	*E*	3,770	113	very good	2,000	125	very good
	H	3,660	110	regular	1,300	75	regular
Check	*T*	3,330	100	—	1,600	100	—

NOTE: Yield values refer to dry matter.

BHC almost reached the same level (mainly with the highest dose *E*), but the already mentioned set-backs make it useless.

Chlordan proved not so well as Dieldrin, but it can be used when the former is not available.

Reinforcing the conclusions already delineated in this chapter, it is observed that the largest gains in yield, sometimes up to three-fold the checks, are registered in the II and III soil types (see Table VI). These two soil types are undoubtely less adapted to yellow lupin growing, showing low yield levels; the average yields from the best treatments ranked below the check of the soil type I (3,330 kg/ha dry matter).

As far as yield is concerned, the comparison of the indices allow the verification that, with the exception of the lowest doses

of Chlordan and BHC, in case of soil types II and III, all the others reached levels of control of the pests and consequent gain of yield quite satisfactory. The fact that in both classifications (regarding infestation and yield) the effects of each insecticide are almost arranged according to the dose used in the same order, gives higher plausibility to the results, showing that they are undoubtely due to the protective action.

Insecticide residual effects

The persistence in the soil of the pest controlling action of the insecticides was given deep concern, as it would allow to skip one application when the action lasts for two years. After the rejection of the practice of two consecutive yellow lupin crops in the same ground, however, only the persistence for at least three crop years was of practical interest, assuring the protection of two yellow lupin crops with only one application.

In order to carry out the experiments concerning the residual action of the insecticides it was necessary to recognize from year to year the plot borders of the experimental fields.

During the first years the experimental design was redrawn from a few stakes left at known points. Soon it was noticed, however, that if this system worked satisfactorily from one year to the next, it was not reliable for a longer period, since the stakes risked then to be removed during the tillage. On account of that, the use of deep buried small stakes was adopted; each stake being provided with 2 wires that reached some inches above the ground and, even when disturbed by the plough or the harrow, led easily to the right point of the unmoved stake.

The first observations dealt with BHC, as shown at Table X, in which the trial carried out in Field « A » for the Pègões Experimental Center is the only one not referred in the preceding sections. On Table X it can be recognized a marked controlling effect of this insecticide even during the fifth year of consecutive yellow lupin crops, which means 3.5 years after the application of the insecticide.

This effect is even more striking considering that it was found out in a Type I soil, which is of sandy texture practically throughout the profile, a soil heavily washed by the winter and spring rains and suffering the dry summer extreme temperatures — all this in a very acid condition.

This lasting effect of BHC (6 kg/ha dose) would have led us to adopt it, except for its lack of control of the *Noctuae* and the off-flavour that tainted the subsequent crops.

TABLE X

Mean values for percentage (index I) of infestation by the Sitona *larvae showed on the third sampling in the same plots. Soil type I*

Insecticide	Symbol and dose	Pègões Exptl. Center (Field «A»)					Pègões Exptl. Center (Field «F»)	
		1948-49	1949-50	1950-51	1951-52	1952-53	1951-52	1952-53
Dieldrin	*P* — 6 kg/ha (1)	—	—	—	—	—	2	30
	N — 4 »	—	—	—	—	—	3	37
	M — 2 »	—	—	—	—	—	18	68
Chlordan	*L* — 2.5 l/ha (2)	—	—	—	—	—	4	71
	D — 1.5 »	—	—	—	—	—	10	68
BHC	*G* — 150 kg/ha (3)	6	7	13	28	43	—	—
	E — 75 »	18	16	66	58	65	3	82
Check	*T* — No insecticide	99	99	99	99	97	57	99

(1) 25 % wettable powder.
(2) 75 % emulsion.
(3) 'Agrocide', dosing 0.45 % of γ BHC.

Chlordan and Dieldrin were equally tested for the residual capacity; the results are given on Tables X and XI, with data collected according to the soil types.

Through a simple reading of Tables X and XI it can be recognized that:

— Chlordan only with the heaviest concentration (2.5 l/ha) showed some residual effect of practical consideration, mainly for the 2 years period; but always inferior to Dieldrin.

— Dieldrin showed, with the two upper doses, a quite satisfactory protection, even in the two years period. Its effects are particularly marked when the index II is considered.

So it can be seen that Dieldrin allows protection to two crops in the field, cutting the cost to the half.

TABLE XI

Mean values for percentage (index II) of infestation by the Sitona *larvae showed on the third sampling. Soil type III*

Insecticide	Symbol and dose	Pègões Velhos (¹)		Pègões Experimental Center					
				Field «I»			Field «H»		
		1952-53	1954-55	1949-50	1950-51	1951-52	1950-51	1951-52	1950-51
Dieldrin	*P* — 6 kg/ha (²)	3	13	—	—	—	—	—	—
	N — 4 »	8	10	—	—	—	—	—	—
	M — 2 »	14	36	—	—	—	31	2	27
Chlordan	*L* — 2.5 l/ha (²)	10	41	—	—	—	22	5	47
	D — 1.5 »	19	47	48	86	90	—	4	68
	I — 0.75 »	—	—	77	86	87	—	8	—
BHC	*G* — 150 kg/ha (²)	—	—	11	25	57	—	—	—
	E — 75 »	4	38	41	73	73	31	18	11
	H — 25 »	—	—	85	83	87	—	14	—
Check	*T* — No insecticide	38	53	99	95	79	99	18	53

(¹) Soil type II; mean values over all ploughing and fertilizer treatments.
(²) Same as in Table X.

Palatability of potatoes grown on soils previously treated with insecticides

In order to evaluate the possible side-effects, mainly off-flavours, potatoes were planted on the experimental fields where the three principal insecticides had been formerly tried for the control of the insect pests of the lupins.

The potato tubers grown there were collected carefully to prevent any possible contact among the different lots. They were cooked in the usual way, but without salt. Submitted to the apreciation of a panel of at least 10 tasters they were classified under one of the three categories: « no objectionable taste », « objectionable undefined taste not very marked » and « very objectionable taste ».

BHC showed an intense mouldy off-flavour in all replications and doses (*G* and *E*) on potatoes grown in soils treated the

previous year. After three years, this flavour was still so objectionable as to prevent their eating.

Dieldrin and Chlordan in the used doses (*M*, *N*, *P* and *L*, *D*, respectively) did not cause any particular taste or smell in the potatoes grown the subsequent year as to prevent their eating.

SUMMARY

The damages caused by the insect pests to the yellow lupin crop grown in the sandy soils south of the river Tagus affect both the yield and the quality of the fodder.

As far as the pests are concerned, it is recognized the regular appearance, year after year, of the root nodules weevils (*Sitona gressorius* F. and *S. griseus* F.), with variable infestation, but mostly close to 100 %.

The seedlings fly (*Hylemya cana* Meig) appears practically every year, showing infestations and damages on varied levels, but normally well supported by a small percentage of the seed planted.

The *Noctuae* or cutworms, with irregular appearances, cause, during the outbreak years, the heaviest damage, someti nes total.

The experiments dealing with insecticides for the control of these pests where carried out during five years with about 35 experimental fields distributed all over the pliocenic and miocenic area south of the river Tagus. BHC, Chlordan and Dieldrin were the insecticides tested.

Considering all the aspects of control, Dieldrin used at the 6 kg/ha (25 % w. p.) level showed the best results of all insecticides tested (see Tables III-V and IX) — because of:

a) *Sitona* control over 80 %
b) High cutworm control, mainly in the first instars
c) Satisfactory *Hylemya* control
d) Acceptable residual effect, until at least two years after the application.

From the practical standpoint, this dose can be safely reduced to the immediatly inferior (4 kg/ha), without noticeable reduction of its action. Probably even the 3.5 kg/ha level can be used for satisfactory control. When Dieldrin is not available, Chlordan can be used in the dose of 7.5 kg/ha (25 % w. p.).

The residual action of the insecticides was particularly striking in the case of BHC: 3.5 years after its application, a good control of the *Sitona* larvae was still noticed.

Dieldrin, with the highest dose, was active after 2 years of application, as opposed to Chlordan, with no practical toxic effect. This gives strong support to the adoption of Dieldrin, since one application may be skipped when two consecutive crops of yellow lupin have only one intermediate crop.

SUMÁRIO

Os estragos causados pelas pragas de insectos à cultura da tremocilha nos terrenos arenosos ao sul do Tejo reflectem-se numa diminuição de produção e na qualidade da forragem, com redução do teor do azoto.

Quanto às pragas, reconhece-se o carácter permanente, ano a ano, do ataque dos gorgulhos das nodosidades (*Sitona* spp.) com intensidade variável, mas predominância dos anos de forte ataque (quase 100 %).

A mosca das plântulas (*Hylemya cana* Meig) surge pràticamente todos os anos, com grau de ataque muito variável, mas perfeitamente suportável à custa de um pequeno excedente de semente lançada à terra.

As noctuas ou roscas, de aparecimento muito irregular, causam, nos anos de surto, os maiores prejuízos, que chegam a ser totais.

Os ensaios com insecticidas contra estas pragas foram instalados, durante 5 anos, em perto de 35 campos, distribuídos por toda a área do pliocénico e miocénico ao sul do Tejo.

O BHC, a Clordana e a Dieldrina foram os insecticidas ensaiados.

Como meio de luta artificial, o insecticida que mais eficaz se mostrou no conjunto de efeitos foi a Dieldrina, na modalidade de 6 kg/ha de pó molhável a 25 % (Tabelas III, IV, V e IX).

De facto, foi de todas as modalidades ensaiadas aquela que mostrou possuir em melhor grau os seguintes atributos:

— Controle dos *Sitonas*, em nível superior a 80 %;
— » das *Noctuas* próximo dos 100 %, sobretudo nas primeiras idades;
— » das *Hylemyas*, em plano razoável.

Na prática, esta dose pode reduzir-se com segurança à dose imediatamente inferior (4 kg/ha), sem diminuição sensível dos seus efeitos.

Cremos mesmo que se poderá descer sem inconveniente aos 3,5 kg/ha. Na falta de Dieldrina poderá usar-se, ainda com resultado, a Clordana, com as mesmas características mas em menor grau, nas doses de 7,5 kg/ha de pó molhável a 25 %.

O efeito residual dos insecticidas foi sobretudo evidente para o BHC, que ao fim de 3,5 anos da sua aplicação ainda mostrava marcado controle dos sitonas.

A Dieldrina, nas doses mais elevadas, mostrou acção residual suficiente ao fim de dois anos, ao contrário da Clordana. Este aspecto mais confirma a acção da primeira, pois permite assim evitar um tratamento quando duas culturas sucessivas de tremocilha no mesmo terreno estejam separadas apenas por um ano de outra cultura.

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ENSAIOS COM MICROTALHÕES

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O recurso aos ensaios com pequenos talhões, idealizado, por questões óbvias de economia, e aperfeiçoado, nos países com reconhecidas tradições nos sectores do melhoramento de cereais e de plantas forraginosas, tem-se generalizado às mais diversas culturas e encontra-se referido a cada passo, nos planos de melhoramento de plantas das instituições que se ocupam de trabalhos desta natureza.

Este processo permite, de facto, instalar, com fins comparativos, grande quantidade de material, na menor área de terreno possível e, segundo parece, com razoável eficiência estatística, desde que se eliminem factores que possam introduzir heterogeneidade nos ensaios.

É assim que são apreciadas preliminarmente, nas estações de melhoramento, as novas variedades importadas, as linhas puras obtidas e as descendências híbridas, nas sucessivas fases de selecção, e que se realizam, ainda, os primeiros ensaios regionais de apuramento das novas criações que se julguem mais apropriadas a determinada zona dum território.

Estudos genéticos, relacionados com a selecção, podem igualmente ser conduzidos nesta base. HUTCHINSON (1940), por exemplo, discute um ensaio comparativo de linhas seleccionadas de algodão, em que utilizou microtalhões e em que mostra a elevada relevância do esquema adoptado na detecção da variância genética e na apreciação dos resultados da selecção.

Os microtalhões adaptam-se particularmente a esquemas estatísticos como os «lattices» que, doutra forma, exigiriam grandes extensões de terreno e elevada quantidade de semente, incompatível com a produção individual das plantas-mães, no caso especial da comparação de linhas, nas primeiras fases da selecção.

Os tipos de microtalhões são muito numerosos, variando os seus tamanhos conforme as áreas disponíveis e os objectivos em vista. Para uso em ensaios de produção e de demonstração, junto da lavoura, que permitam comparações suficientemente precisas, HARRINGTON (1952) indica, por exemplo, dois tipos de microtalhões, os da classe M e os da classe A, ambos com 3,5 m de comprimento constando o primeiro de 5 filas para sementeira ou plantação, afastadas entre si de 20 cm, e o segundo de 4 filas afastadas de 30 cm.

Para estudos comparativos de descendências provenientes de plantas seleccionadas, quer sob o aspecto da produção, quer quanto à resistência a doenças, menciona o mesmo autor os talhões da Classe H e da classe R, com 1 a 2 filas de plantas apenas e com comprimentos variáveis de 1 a 3 m, constituindo pròpriamente o que se poderá chamar « talhões de melhoramento » cujo conjunto, dentro dum ensaio, constitui os « nurseries ».

No melhoramento do arroz, em virtude do condicionamento da área disponível, já há anos que se recorre, na Estação Agronómica Nacional, ao expediente dos microtalhões, em ensaios preliminares de produção de linhas seleccionadas.

Todavia, a precisão satisfatória, conseguida noutros países, não tem sido alcançada por motivo das condições de trabalho, em que o ataque de roedores e de pássaros, na época de maturação do arroz, criando problemas de control ainda sem resolução cabal, afectam notàvelmente as produções das pequenas áreas.

Referimos aqui dois desses ensaios de campo, destinados à escolha e eliminação prévia de material, nos quais se pretendeu comparar, quanto à produção e quanto ao ciclo vegetativo (que não é aqui considerado), 19 cultivares da ssp. *sativa* e da ssp. *japonica* tipo *longa*, existentes na colecção e representadas, cada uma, por uma linha pura, e discutem-se algumas possibilidades de aumentar a sua eficiência.

MATERIAL E MÉTODOS

Nestes ensaios usou-se como testemunha a linha 177 de 'Chinês', o arroz que ocupa a maior área orizícola do País.

As cultivares a comparar eram as seguintes: 'Aljubarrota', 'Alorna', 'A. Chiapelli', 'Belém', 'Chinês', 'D. Sancho', 'Família 181', 'Grosa', 'Laboratório 7', 'Mantova', 'Razza 77', 'Rinaldo Bersani', 'Razza 91', 'Razza 115', 'Razza 27' e 'Razza 82'.

Os ensaios deviam realizar-se durante três anos, mas os resultados do último ano foram desperdiçados.

Para economia de terreno, cada talhão era constituído por 2 fileiras, com 3,5 m de comprido, afastadas de 0,20 m, sendo a distância entre plantas, na fila, de 0,10 m, e a largura das ruas de 0,50 m.

O esquema utilizado foi o dos blocos casualizados com um número bastante elevado de repetições (10), a título experimental, para se atenuar o erro provocado pela influência do meio sobre talhões pequenos.

No entanto, impuzeram-se desde logo algumas limitações. Os viveiros de algumas cultivares perderam-se no primeiro ano do ensaio, e as últimas repetições, para uma parte delas, foram eliminadas, só se aproveitando, por último, os dados de 4 blocos e de 6 blocos, como veremos. No ano seguinte renovou-se o ensaio com aqueles arrozes e apenas em 6 repetições, mas não se plantaram alguns deles porque os viveiros não forneceram o número necessário de plantas.

Para as produções se tornarem comparáveis era ideal que se pudesse contar, em todos os talhões, com o mesmo número de plantas (70). Isso porém não aconteceu, porque, nuns casos, apesar da retancha, muitas falharam, e noutros casos, como já dissemos, os ratos e os pássaros causaram estragos, antes da colheita, de preferência nas formas mais precoces, donde resultou ter de tomar-se em conta sòmente as plantas intactas.

Surgiram daí duas possibilidades. Uma era a de colher-se, em cada talhão, uma quantidade certa de plantas, condicionada pelo talhão mais afectado. Esta apreciação tornava-se morosa e podia levar a um número relativamente baixo de indivíduos e a consequente aumento do erro do ensaio.

A outra consistia em utilizar a produção média por planta em cada talhão aproveitando o número, muito variável, de plantas não eliminadas.

Não sabiamos, porém, até que ponto o número de plantas poderia influir na produção média. Assim, a par da determinação das diferenças de produtividade, objectivo dos ensaios, resolvemos eliminar, tanto quanto possível, essa influência provável, servindo-nos do método da covariância, indicado em SNEDECOR (1945).

As variáveis consideradas foram a quantidade das plantas colhidas em cada talhão (X) e a respectiva produção total (Y).

RESULTADOS E DISCUSSÃO

1.º ano de ensaio

O número diferente de repetições que foi possível aproveitar na época da colheita, para as cultivares ensaiadas, facultou-nos o

QUADRO I

Totais das produções (SY) e do número de plantas, (SX), por cada cultivar e por repetição

Grupo I (11 cultivares × 6 repetições)			Grupo II (14 cultivares × 4 repetições)		
	SX	SY (g)		SX	SY (g)
'Aljubarrota'	257	1603	'Aljubarrota'	169	1081
'Chinês'	336	5423	'A. Chiapelli'	159	1590
'D. Sancho'	273	2761	'Belém'	179	2580
'Laboratório 7'	249	2158	'Chinês'	210	3416
'Soure'	276	2994	'D. Sancho'	188	1868
'Rinaldo Bersani'	302	3310	'Laboratório 7'	173	1520
'Razza 77'	359	4247	'Mantova'	163	2127
'Razza 91'	351	4134	'Razza 77'	232	2876
'Razza 115'	316	2837	'Soure'	171	1974
'Razza 27'	291	3870	'Rinaldo Bersani'	191	2179
'Razza 82'	294	3021	'Razza 91'	234	2466
			'Razza 115'	205	1760
			'Razza 27'	189	2557
			'Razza 82'	204	2193
Totais gerais	3304	36358		2667	29897

Totais para repetições

Grupo I

1.ª rep.		*2.ª rep.*		*3.ª rep.*		*4.ª rep.*		*5.ª rep.*		*6.ª rep.*	
SX	SY	SX	SY	SX	SY	SX	SY	SX	SY	SX	SY
395	4310	614	6171	523	5965	634	7154	541	6237	597	6521

Grupo II

1.ª rep.		*2.ª rep.*		*3.ª rep.*		*4.ª rep.*	
SX	SY	SX	SY	SX	SY	SX	SY
497	5414	754	8195	668	7863	748	8425

seu arranjo em dois grupos e o estudo da eficiência do número de blocos neste tipo de ensaio.

Um dos grupos foi constituído por 11 cultivares representadas em 6 repetições (Grupo I) e o outro por 14 cultivares apenas com 4 repetições (Grupo II).

Os totais relativos aos dados das produções e do número de plantas colhidas, destes dois grupos, encontram-se no Quadro I.

Por uma análise vulgar da variância das produções ficar-se-ia sem saber se a variação das médias deveria ser, totalmente ou só em parte, atribuível à variação do número de plantas por talhão, aliás com diferenças altamente significativas (Quadro II).

QUADRO II

Análise da variância do número de plantas por talhão num ensaio com 6 repetições

Variação	g. l.	s. q.	q. m.
Blocos	5	3472,16	694,43 **
Cultivares	10	2251,40	225,14 **
Erro	50	2308,24	46,16

Como se verifica, porém, pela análise da covariância, resumida no Quadro III, existem diferenças significativas, entre as produções médias das cultivares, tendo por base um mesmo número de plantas, pelo que as variações nas produções devem atribuir-se especialmente às características das cultivares.

O ensaio de significância das diferenças foi aplicado às médias, ajustadas ao número de plantas por talhão, registadas no Quadro IV, e obtidas, como se sabe, por subtração do produto *bx* do coeficiente de regressão do erro pelos desvios para a média experimental do número de plantas ($x = X - X$).

Dos valores encontrados verifica-se que, apesar do ajustamento, não se deram alterações muito sensíveis na ordem das produções, a não ser na de 'Razza 27', que de 4.º passou para 2.º.

Como a diferença mínima de significância (a 5 %) foi:

$$d = t_{(49)} \; s_{dm} = 2{,}009 \times 63{,}21 = 126{,}9 \text{ g}$$

QUADRO III

Resumo da análise da covariância entre o número de plantas e a produção, no Grupo I

Variação	g. l.	Sx^2	Sxy	Sy^2	Erros de avaliação		
					g. l.	s. q.	q. m.
Blocos	5	3472,16	35739,32	411640,54			
Cultivares	10	2251,40	52868,52	1881074,14			
Erro (dentro das cultivares)	50	2308,24	18553,68	738393,86	49	589258,19	12025,67
Total	65	8031,80	107161,52	3031108,54			
Cultivares + Erro	60	4559,64	71422,20	2619468,00	59	1500710,03	
Diferenças para o ensaio das médias das produções ajustadas					10	911451,83	91145,18

$F = 7,579$ ** $\qquad s_e = 109,6$

QUADRO IV

Cálculo das produções médias ajustadas ao número de plantas no Grupo I

Cultivares	Número médio de plantas por talhão $\bar{X}$	Desvio para a média geral x	b. x	Produções médias por talhão $\bar{Y}'$		Produções médias ajustadas $\bar{Y} = \bar{Y}' - b.\ x$
'Chinês'	56,0	6,0	48,22	903,83	(1)	855,61
'Razza 27'	48,5	— 1,5	— 12,05	645,00	(4)	657,05
'Razza 77'	59,8	9,8	78,77	707,83	(2)	629,06
'Razza 91'	58,5	8,5	68,32	689,00	(3)	620,68
'Soure'	46,0	— 4,0	— 32,15	499,00	(7)	531,15
'R. Bersani'	50,3	0,3	2,41	551,66	(5)	529,25
'Razza 82'	49,0	— 1,0	— 8,03	503,50	(6)	511,53
'D. Sancho'	45,5	— 4,5	— 36,17	460,16	(9)	496,33
'Razza 115'	52,6	2,6	20,89	472,83	(8)	451,94
'Laboratório 7'	41,5	— 8,5	— 68,32	359,66	(10)	427,98
'Aljubarrota'	42,8	— 8,2	— 57,87	267,16	(11)	325,03

$x = 50,0; \qquad b = 8,038$

os arrozes ensaiados puderam distribuir-se, pela ordem crescente das médias ajustadas, em 5 grupos, um, bem definido, formado ùnicamente pelo 'Chinês' cuja produção não foi atingida por qualquer das outras cultivares, outro, pelo 'Aljubarrota' e pelo 'Laboratório 7', no fim da escala, e 3 mais amplos, que englobaram todos os arrozes de produção intermédia e em que 'Razza 27' se distinguia de 'Rinaldo Bersani' e das cultivares que se seguem.

O erro experimental de 19,9 %, não permitiu que se evidenciassem diferenças suficientemente significativas dentro destes grupos. No entanto 'Razza 27', 'Razza 77' e Razza 91' tenderam a destacar-se dos restantes, devendo considerar-se provàvelmente como os arrozes de melhor produção em seguida ao 'Chinês'.

Para o arranjo que constituíu o Grupo II, fizeram-se cálculos semelhantes, indicando a análise da covariância, resumida no Quadro V, que, da mesma maneira, o ensaio foi significativo, quando se considerou a correlação entre o número de plantas por talhão e a produção.

O coeficiente de correlação, neste caso, é ligeiramente superior ao que se achou no Grupo I e verifica-se, como se observa no

QUADRO V

Resumo da análise da covariância entre o número de plantas e a produção, no Grupo II

Variação	g. l.	Sx^2	Sxy	Sy^2	Erros de avaliação		
					g. l.	s. q.	q. m.
Total	55	7783,13	91772,4	2328202,13			
Blocos	3	3063,63	35024,8	415654,13			
Cultivares	13	1856,38	28704,9	1135713,13			
Erros (dentro das cultivares)	39	2853,12	28042,7	776834,87	38	501231,22	13190,29
Cultivares + Erro	52	4709,50	56747,6	1912548,00	51	1228763,00	
Diferenças para o ensaio das médias das produções ajustadas					13	727531,78	55963,98

$F = 55963{,}98 / 13190{,}29 = 4{,}242^{**}$ $s_e = 118{,}8$

Quadro VI, algumas alterações na ordem das produções ajustadas, em comparação com o Quadro IV.

Assim, 'A. Chiapelli', que ocupava o 12.º lugar, melhorou para 10.º. 'Mantova' deslocou-se do 8.º lugar para o 4.º, 'Soure', que estava em 9.º, passou para 7.º e assim sucessivamente, como se indica no Quadro VI.

Neste caso, a diferença mínima de significância a (5 %) foi de:

$$d = t_{(38)} \cdot s_{dm} = 2{,}024 \times 81{,}21 = 164{,}3 \text{ g}$$

A observação da ordem das médias ajustadas permite-nos verificar então que, a não ser o 'Chinês', que se diferencia significativamente dos restantes arrozes excepto do 'Belém' que foi o 2.º no valor da produção, não se definiu qualquer grupo absolutamente isolado dos outros. No entanto 'A. Chiapelli', 'D. Sancho', 'Laboratório 7', 'Razza 115' e 'Aljubarrota', constituem um agrupamento de arrozes com fraco rendimento, sendo o 'Aljubarrota' nìtidamente inferior.

QUADRO VI

Cálculo das produções médias, por talhão ajustadas ao número de plantas, no Grupo II

Cultivares	Número médio de plantas $\overline{X}$	Desvio para a média geral x	b. x	Produções médias $\overline{Y}$'		Produções médias ajustadas $\overline{Y} = \overline{Y}' - b. x$
'Chinês'	52,2	4,9	48,16	854,00	(1)	805,84
'Belém'	44,7	— 2,9	— 28,50	645,00	(3)	673,50
'Razza 77'	58,0	10,4	102,21	719,00	(2)	616,79
'Mantova'	40,7	— 6,9	— 67,81	531,75	(8)	599,56
'Razza 27'	47,2	— 0,4	— 3,93	564,25	(5)	568,18
'R. Bersani'	47,7	0,1	0,98	547,25	(7)	547,27
'Soure'	42,7	— 4,9	— 48,16	493,50	(9)	541,66
'Razza 82'	51,0	3,4	33,41	548,25	(6)	514,84
'Razza 91'	58,5	10,9	107,13	616,50	(4)	509,37
'A. Chiapelli'	39,7	— 7,9	— 77,64	397,50	(12)	475,14
'D. Sancho'	47,0	— 0,6	— 5,89	466,00	(10)	471,89
'Laboratório 7'	43,2	— 4,4	— 43,24	380,00	(13)	423,29
'Razza 115'	51,2	3,6	35,38	440,00	(11)	404,62
'Aljubarrota'	42,2	— 5,4	— 53,07	270,25	(14)	323,32

$\overline{X} = 47{,}6$ $\quad b = 9{,}8287$

O erro experimental deste arranjo, no valor de 21,5 % e um tanto superior ao da outra modalidade, não permitiu comparações mais precisas.

O exame das variâncias do erro do ensaio (variação dentro das cultivares) nos dois arranjos 11×6 e 14×4 pode dar-nos algumas indicações sobre a vantagem em se ter considerado o variante « Número de Plantas » sob o aspecto da regressão para a produção.

Do Quadro VII conclui-se que, em ambos os casos, ao consi-

QUADRO VII

Análise da variância do erro nas produções dos arranjos 11×6 e 14×4

Variação	11 cultiv. × 6 rep.			14 cultiv. × 4 rep.		
	g. l.	s. q.	q. m.	g. l.	s. q.	q. m.
Erro (dentro das cultivares-médias não ajustadas), Sy^2	50	738393,86	14771,87	39	776834,87	19918,84
Devido à regressão, $(Sxy)^2 / Sx^2$	1	149135,66	149135,66	1	275603,65	275603,55
Erro para as médias ajustadas	49	589258,20	12025,67	38	501231,22	13190,29

$F_1 = 149135,66 / 12025,67 = 12,40$ ** ; $F_2 = 275603,65 / 13190,29 = 17,25$ **

QUADRO VIII

Análise da variância baseada na produção média por planta e por talhão

Variação	11 × 6 Grupo I				14 × 4 Grupo II			
	g. l.	s. q.	q. m.	F	g. l.	s. q.	q. m.	F
Total	65	674,42			55	620,83		
Blocos	5	13,60	2,72		3	5,60	1,86	
Cultivares	10	423,71	42,37	8,93 **	13	353,14	27,16	4,04 **
Erro	50	237,11	4,74		39	252,09	6,72	
	d (5 %) = 3,1 g				d (5 %) = 3,7 g			

derarmos os valores das duas partes de que se compõe o erro, a variância devida à regressão linear foi altamente significativa, ficando o quadrado médio relativo ao erro reduzido em cerca de 20 %, no primeiro caso, e de 40 % no segundo caso.

Em vez de se trabalhar com as produções por talhão, ajustadas ao número de plantas, conseguir-se-iam resultados seme-

QUADRO IX

Comparação dos resultados obtidos pelos dois processos de análise

Grupo I			Grupo II		
Cultivares	Produções médias por planta (g) em ordem crescente	Ordem de classificação obtida com a regressão	Cultivares	Produções médias por planta (g) em ordem crescente	Ordem de classificação obtida com a regressão
'Chinês'	16,3	1.º	'Chinês'	16,4	1.º
'Razza 27'	13,4	2.º	'Belém'	13,9	2.º
'Razza 77'	11,9	3.º	'Mantova'		4.º
'Razza 91'	11,8	4.º	'Razza 77'	12,4	3.º
'R. Bersani'	11,0	6.º	'Razza 27'	12,3	5.º
'Soure'	10,8	5.º	'Soure'	11,6	7.º
'D. Sancho'	10,2	8.º	'R. Bersani'	11,5	6.º
'Razza 82'		7.º	'Razza 82'	10,7	8.º
'Razza 115'	8,8	9.º	'Razza 91'	10,6	9.º
'Laboratório 7'	8,3	10.º	'D. Sancho'	10,1	11.º
'Aljubarrota'	6,2	11.º	'A. Chiapelli'	9,9	10.º
			'Razza 115'	8,6	13.º
			'Laboratório 7'	8,3	12.º
			'Aljubarrota'	6,3	14.º

lhantes na separação de grupos de cultivares, considerando a produção média por planta em cada talhão?

A análise da variância feita neste sentido, em ambos os arranjos, indica-nos uma variação não significativa na produção média por planta, entre os blocos, e uma diferença altamente significativa na produção média das cultivares (Quadro VIII). O símbolo *d* representa a diferença mínima de significância para a comparação das médias.

Dispostas estas por ordem crescente de valores, em ambos os

casos, no Quadro IX, observam-se, em primeiro lugar, ligeiras alterações na distribuição das cultivares em relação à que se obteve com a regressão.

Em segundo lugar, esta diferenciação dos agrupamentos, comparada com a que representámos nos Quadros IV e VI, é também um pouco diferente, em parte, como consequência das modificações na ordem das médias. No Grupo I é notória, todavia, a falta de eficiência na separação entre 'Razza 27' e 'Chinês', e entre 'Aljubarrota' e 'Razza 115', que se conseguiu com a regressão para o número de plantas (V. Quadro IV).

As conclusões desta rápida análise parecem abonar a favor dos cálculos que tomem em consideração o efeito da variação do número de plantas sobre a produção, nos pequenos talhões incompletos.

Quanto à vantagem do número de repetições ter sido aumentado de 4 para 6, conduzindo a um maior número de graus de liberdade para o erro, verifica-se que a s. q. para esta verba é ligeiramente superior no primeiro caso (Grupo II — Quadro VI), o que não basta para esclarecer a questão. No entanto, o erro experimental do ensaio foi mais elevado, com menos repetições, e a distinção dos arrozes menos precisa. Se compararmos, ainda, nas duas modalidades, as médias ajustadas relativas aos arrozes, que se encontram representados em ambos os arranjos, verificamos que não coincidem, visto que o diferente número de repetições há-de influir certamente nas médias. Observa-se até que, no caso de 6 blocos, a ordem das produções ajustadas se aproxima mais da ordem das produções médias por planta.

Para ensaios nestas condições podemos pois optar, com vantagem, por um número de repetições não inferior a 6.

Ensaio do 2.º ano

Empregando 6 blocos casualizados, de acordo com os resultados do ano anterior, comparam-se as produções de 14 cultivares, utilizando o maior número possível de plantas, em cada talhão, e entrando com a regressão desses números para a produção por talhão.

Os totais, necessários à análise da variância, e o resumo desta, indicam-se nos Quadros X e XI, respectivamente.

QUADRO X

Totais das produções (g) e do número de plantas num ensaio de 14 cultivares com 6 repetições

	SX	SY
' Aljubarrota '	334	3165
' Alorna '	320	4626
' A. Chiapelli '	314	3983
' Belém '	350	5179
' Chinês 177 '	385	5625
' D. Sancho '	375	4457
' Família 181 '	255	2342
' Grosa '	333	3171
' Laboratório 7 '	283	1655
' Mantova '	353	4697
' Razza 77 '	257	2370
' Rinaldo Bernani '	315	4257
' Razza 115 '	366	3120
' Razza 82 '	347	5085
Totais gerais	4617	53732

		1.ª rep.	*2.ª rep.*	*3.ª rep.*	*4.ª rep.*	*5.ª rep.*	*6.ª rep.*
Totais para repetições	SX	804	801	757	759	748	748
	SY	9326	9728	9276	8018	9095	8289

QUADRO XI

Análise da covariância no ensaio do 2.º ano

Origem da variação	g. l.	Sx^2	Sxy	Sy^2	Erros de avaliação		
					g. l.	s. q.	q. m.
Total	83	6355	121454	5651679			
Blocos	5	241	3877	155667			
Cultivares	13	3545	78867	3176184			
Erro (dentro das cultivares)	65	2569	38710	2319828	64	1736542	27133
Cultiv. + erro	78	6114	117577	5496012	76	3234915	
Diferenças para o ensaio das médias das produções ajustadas					13	1498373	115259

$F = 4,247^{**}$ $\qquad s_e = 164,7$

Obtiveram-se diferenças altamente significativas para as médias das produções, ajustadas pelo processo usual, com um coeficiente de regressão b 15,06, sendo a diferença mínima de significância (ao nível de 5 %):

$$d = 189{,}5 \text{ g}$$

o que permitiu os seguintes agrupamentos de produções, indicadas pelas chavetas:

'Belém'	811,9
'Razza 82'	803,8
'Chinês 177'	789,9
'Alorna'	795,1
'Rinaldo Bersani'	745,7
'Mantova'	724,1
'D. Sancho'	628,3
'A. Chiapelli'	627,7
'Família 181'	577,2
'Razza 77'	574,3
'Grosa'	519,5
'Aljubarrota'	516,9
'Razza 115'	428,1
'Laboratório 7'	393,4

Salienta-se, em relação ao ano anterior, a subida do 'Razza 82' para 2.º lugar e a descida do 'Razza 77'. A diminuição na produção do 'Chinês 177', testemunha do ensaio, deve atribuir-se a deficiência das condições culturais, durante a granação.

Dos arrozes que puderam ser incluidos pela primeira vez neste género de ensaios de produção, evidenciou-se a posição do 'Alorna', um arroz bastante precoce, e os rendimentos medianos dos 'Grosa' e 'Família 181'.

* * *

Como estes ensaios tinham por objectivo a separação de arrozes com produções de interesse provável e a eliminação imediata dos que mostrassem fracas possibilidades, antes de qualquer experimentação, em maior escala, parecia vantajoso aproveitarem-se as informações obtidas quanto às cultivares comuns aos dois anos, fazendo uma análise conjunta dos dados.

A interpretação dos resultados de ensaios semelhantes, repetidos no espaço ou no tempo, apresenta todavia dificuldades que podem invalidar estatìsticamente as comparações das médias, partindo dos dados tal como foram obtidos, exigindo-se testes especiais e até transformações apropriadas. O número diferente de repetições e a falta de homogeneidade dos erros experimentais são condições suficientes para tais modificações. Cochran & Cox (1950) referem-se a estes problemas sugerindo métodos para a sua solução em determinadas circunstâncias, assim como Rojas, Kempthorne, Yates, Oliveira e outros, citados por Oliveira (1958).

No caso presente, o ensaio de significância das duas variâncias do erro, a do 1.º e a do 2.º ano, feito segundo indicação de Snedecor (1956), pelo teste do F, considerando apenas as cultivares comuns aos dois anos, acusa um valor de F $\frac{22248}{10086}$ 2,2, altamente significativo para os graus de liberdade dos erros de avaliação obtidos nos dois anos.

Os erros s_{e_1} 149 e s_{e_2} 100,4 não são homogéneos, portanto, o que levaria à pesquiza, por tentativas, da transformação mais adequada dos dados, provàvelmente a logarítmica, para as produções, e qualquer outra adaptável a contagens de plantas.

Teòricamente, porém, a existência de um único grau de liberdade, para a comparação entre anos, seria insuficiente para a apreciação estatística da interacção anos $\times$ cultivares. Além disso, a simples observação das médias das produções mostra uma certa uniformidade na classificação relativa das cultivares, o que dispensa métodos mais complexos e sugere, só por si, as eliminações a fazer. Como se vê no Quadro XII, 'Aljubarrota', 'Laboratório 7' e 'Razza 115' foram sempre os piores arrozes ensaiados, podendo ser eliminados não só com base nas médias anuais, como também pela média dos dois anos.

Da mesma maneira, a eliminação pode tornar-se extensível às cultivares de produção intermédia em ambos os anos, 'A. Chiapelli' e 'D. Sancho'.

Na parte superior da escala, embora a testemunha não tenha sido suplantada (com excepção do 2.º ano, em que a sua produção baixou, por deficiências culturais), há a considerar que o ensaio englobou formas finas do tipo carolino ou gigante de 1.ª, de maior preço, embora normalmente de rendimentos inferiores à testemunha, que é uma forma comum.

Nesta ordem de ideias, 'Belém' e 'Mantova' são arrozes com

produções de interesse, que deverão figurar em futuros ensaios, o mesmo podendo dizer-se de 'Rinaldo Barsani', de 'Razza 82' e de 'Razza 77', embora o comportamente destes fosse menos concordante nos dois anos.

QUADRO XII

Produções médias (g) das cultivares comuns aos 2 anos de ensaios

1.º ano		2.º ano		Média	
'Chinês'	805,8	'Belém'	811,9	'Chinês'	797,8
'Belém'	673,5	'Razza 82'	803,8	'Belém'	742,7
'Razza 77'	616,8	'Chinês 177'	789,9	'Mantova'	666,8
'Mantova'	599,6	'Rinaldo Bersani'	745,7	'Razza 82'	659,3
'Rinaldo Bersani'	547,3	'Mantova'	724,1	'Rinaldo Bersani'	646,5
'Razza 82'	514,8	'D. Sancho'	628,3	'Razza 77'	595,5
'A. Chiapelli'	475,1	'A. Chiapelli'	627,7	'A. Chiapelli'	551,4
'D. Sancho'	471,9	'Razza 77'	774,3	'D. Sancho'	550,1
'Laboratório 7'	423,3	'Aljubarrota'	516,9	'Aljubarrota'	420,1
'Razza 115'	404,6	'Razza 115'	428,1	'Razza 115'	416,3
'Aljubarrota'	323,3	'Laboratório 7'	393,4	'Laboratório 7'	408,3

CONCLUSÕES

A eficiência dos microtalhões em ensaios preliminares de produção de cultivares ou de linhas seleccionadas de arroz, sempre que se verifiquem grandes diferenças no número de plantas por talhão, devido ao ataque de roedores ou de pássaros, no período da maturação, pode ser aumentada por dois processos:

a) adopção dum número de repetições nunca inferior a 6, no caso de se empregarem blocos casualizados;
b) recurso à covariância, ajustando as produções ao número de plantas intactas.

Em resultado de dois anos de ensaio puderam ser eliminadas as cultivares 'Aljubarrota', 'Laboratório 7' e 'Razza 115' e eleger para ensaios futuros 'Belém', Mantova', 'Rinaldo Bersani', 'Razza 82' e 'Razza 77'.

SUMMARY

In this work some possibilities of rendering more effective the microplots in nursery tests on rice cultivars and strains whenever their plants are damaged by the attack of rodents and birds during the ripening time are considered.

A number of replications not inferior to 6 in randomized blocks as well as the use of covariation in order to adjust, in each plot, the yields to the number of individuals not attacked, have been shown to be advisable in such a conditions.

A trial carried out for 2 years in this way allowed us to promote to next trials, among 10 long and medium grain varieties, some outstanding cultivars as 'Belém', 'Mantova', 'Rinaldo Bersani', 'Razza 82' and 'Razza 77' and to discard safely 'Aljubarrota', 'Laboratório 7', 'Razza 115', 'A. Chiapelli' and 'D. Sancho'.

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